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JOURNAL  
OF  
SOUTH AFRICAN  
BOTANY

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VOLUME 35

1969

*Published under the Authority of the Trustees of the*  
NATIONAL BOTANIC GARDENS OF  
SOUTH AFRICA  
*Kirstenbosch, Newlands, Cape Province*

EDITOR

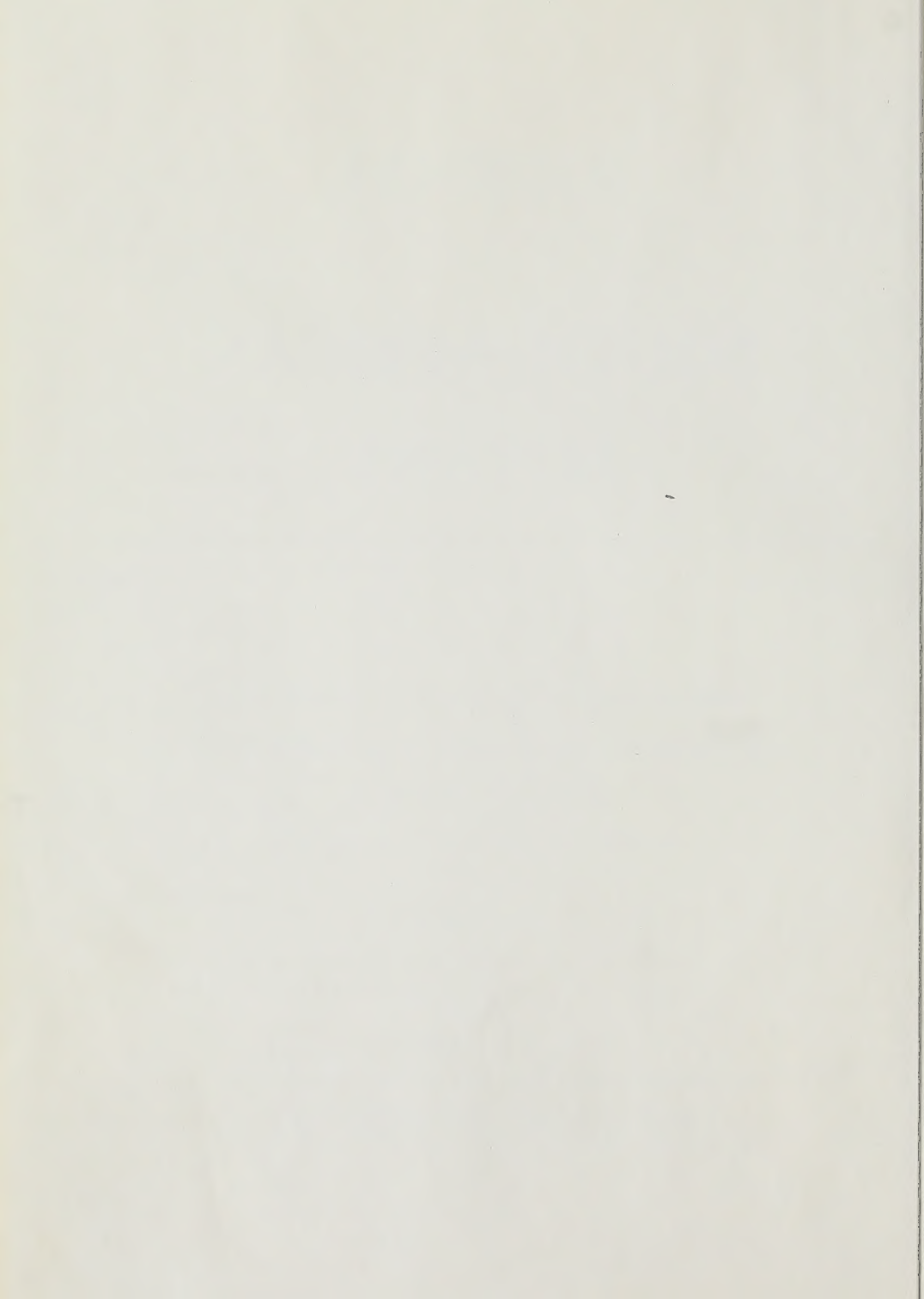
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# JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 35     1969

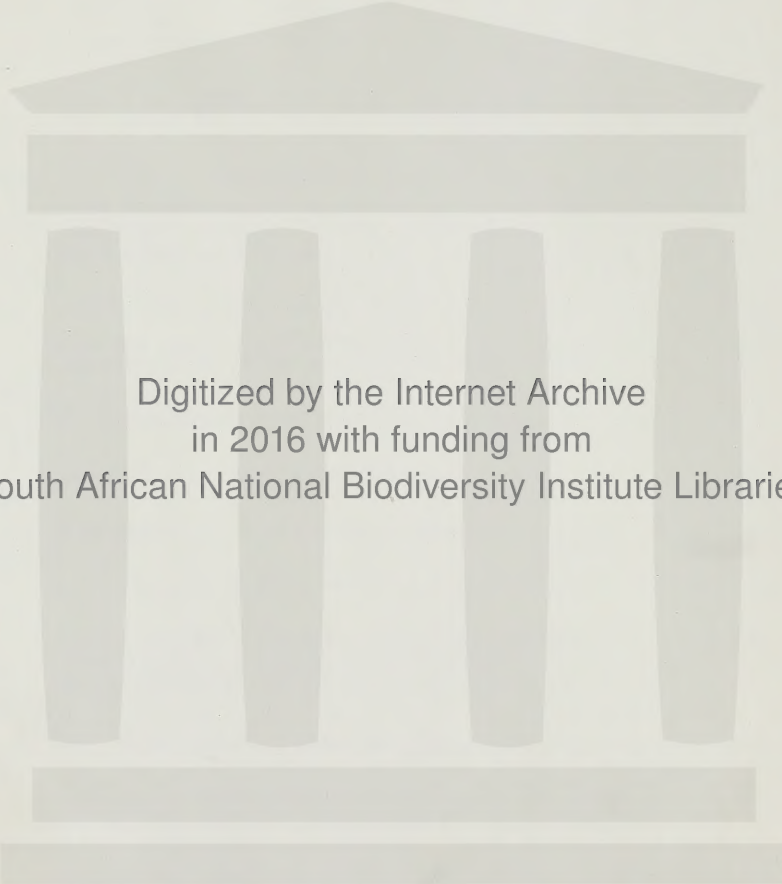
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THIS VOLUME IS DEDICATED TO

**GWENDOLINE JOYCE LEWIS (1909–1967),**

B.A., Ph.D. (Cape Town), F.R.S.S.Af.

(*Botanical Research Officer, Compton Herbarium, Kirstenbosch*), holder of the Edward Muspratt Solly Scholarship at Kirstenbosch in 1932 and 1933, a research worker making significant contributions to the taxonomic study of the family Iridaceae, with many articles on this branch of research to her credit and elected to Fellowship of the Royal Society of South Africa in recognition of her work in botanical science, Curator of the South African Museum Herbarium for 18 years and engaged in the preparation of a major work on *Gladiolus* which was nearing completion at the time of her death.

## JOURNAL OF SOUTH AFRICAN BOTANY

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### CORRIGENDUM

Journal of South African Botany, Vol. 35, Part 1, 1969: "Three New Species and a New Variety of *Erica*" (H. A. Baker) p. 33, Line 25:  
for "*H. A. Baker* 1864" read "*H. A. Baker* 1865".

that the method shows promise as a tool for studying changes in species over time and for determining the ecological status of species, providing that certain conditions are adhered to.

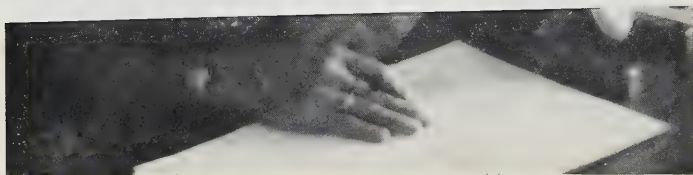
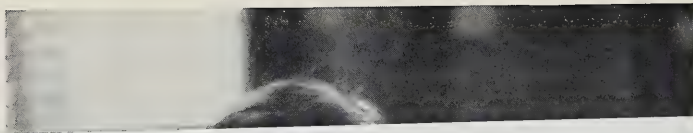
### INTRODUCTION

In addition to assessing the ecological status of species and stands, the phytosociological ordination studies of the Wisconsin School (Curtis & McIntosh, 1951; Bray & Curtis, 1957; Curtis, 1959; Goff & Cottam, 1967) aim to relate the spatial distribution of species and their importance in stands to variations in the environmental complex. The closeness of the relationship is determined by the degree of correspondence between the quantitative distributions of species and selected environmental factors. The environmental factors may, or may not, be causally related to species behaviour, but the procedure provides a basis for generating hypotheses on plant-environment relationships.

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† Accepted for publication 27th June, 1968.





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# JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 35, PART 1

Published: 15TH JANUARY 1969

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## PRELIMINARY ASSESSMENT OF ECOLOGICAL STATUS OF PLANT SPECIES IN THREE SOUTH AFRICAN VELD TYPES †

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### ABSTRACT

A method of ordering plant species by their ecological status, known as Index Iteration, was applied to data from three South African veld types. The raw data consisted of wheel-point analyses from the Bankenveld and the *Cymbopogon-Themeda* Veld, and of density and frequency values from the Valley Bushveld. As the data were not originally collected for this kind of treatment, the results are necessarily tentative. However, it is concluded that the method shows promise as a tool for studying changes in ecological status of stands over time and for determining the ecological status of species, providing that certain conditions are adhered to.

### INTRODUCTION

In addition to assessing the ecological status of species and stands, the phytosociological ordination studies of the Wisconsin School (Curtis & McIntosh, 1951; Bray & Curtis, 1957; Curtis, 1959; Goff & Cottam, 1967) aim to relate the spatial distribution of species and their importance in stands to variations in the environmental complex. The closeness of the relationship is determined by the degree of correspondence between the quantitative distributions of species and selected environmental factors. The environmental factors may, or may not, be causally related to species behaviour, but the procedure provides a basis for generating hypotheses on plant-environment relationships.

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† Accepted for publication 27th June, 1968.

This paper is concerned with the first aim, namely determining the ecological status of species and stands. Ecological status of stands is taken to mean the relative degree of favourableness of the environment for plant growth and productivity. It is largely, but not entirely, related to favourable moisture conditions. A high status implies very favourable conditions for plant growth, whereas a low status implies unfavourable conditions. Species with high ecological status are those which reach their greatest importance in stands with high ecological status and *vice versa* for species with low ecological status.

An article by Goff & Cottam (1967) describing Index Iteration, a method for arranging species, or stands, along axes of floristic variation, was the stimulus for the present account. They obtained thereby an objectively-determined indication of ecological status. In South Africa very little work has been done in this field, hence the need for trial of Index Iteration under local conditions. Available relative basal cover data from the northern variation of the *Cymbopogon-Themeda* Veld and the western variation of the Bankenveld (Veld Types 48b and 61a, respectively, of Acocks, 1953), and relative density and relative frequency data from the northern variation of the Valley Bushveld (Veld Type 23a) were used.

The ecological status of species is determined by ordering them along an axis, according to their quantitative variation over all stands under consideration. Such an ordination of species can be carried out in at least six different ways (Goff & Cottam, 1967), including the original method of "leading dominants" and the "movable plastic strip" method of Curtis & McIntosh (1951). All methods give fairly similar results (Goff & Cottam, 1967). As Index Iteration has the advantages of speed, objectivity and more efficient use of the information content of the data, it was used in this investigation. In Index Iteration, the Importance Values (q.v.) of species are compared for all possible species pairs over all stands. Those species that attain their highest or lowest Importance Values in the same stands will have a high degree of similarity in their ecological requirements and be situated together along the axis. Those not having similar Importance Values in the same stands will, by the same token, be further removed from each other. The species best adapted to unfavourable conditions is represented by the figure one, at one end of the axis, whereas the species best adapted to favourable conditions is represented by the figure ten at the other end. Together with the scaled values in between, these so-called Species Position Indices (SPI) indicate the relative ecological status of each species. When the Importance Values of species in each stand are weighted by their SPI and these products summed, a Stand Synthetic Index (SSI), formerly called the Compositional Index (CI), is obtained for a stand. The SSI obviously should give an indication of the ecological status of the stand. Reference to environmental features generally indicates that this is so.



#### REQUIREMENTS FOR DATA COLLECTION

Stands are required to be homogeneous. This is often determined by means of a chi-squared statistical test (Curtis, 1959). Stands are also required to be free of unnatural disturbance and should adequately represent the floristic composition of the vegetation at any particular spot. Stands reasonably objectively selected from the xerosere and the hydrosere are usually separated for interpretive convenience in analysis. In such stands, the Importance Values of the species are assumed to be a measure of their adaptation to the environment. The Importance Value (IV) is usually, but not necessarily, a composite of relative frequency, relative density and relative dominance (cover).

Curtis and co-workers followed what has been termed the mass collection method (see Curtis & McIntosh, 1951). They believed that "... variation in floristic composition is one of the most important characteristics that may be determined in the study of any vegetation..." (Ibid p. 480). To understand this variation entails the collection of data from a large number of stands (usually 60 or more) within a floristic province. Curtis (1959, p. 600) defines a floristic province as "... a large area with a relatively uniform flora, delimited by a line or zone in which many species reach a common range boundary...". Obviously the concept of the floristic province is necessary, otherwise the absence of a plant species from a stand may be wrongly construed as "unimportance" of the species in the stand, whereas its absence may be a foregone conclusion due to a major and marked environmental discontinuity.

Ideally, stands representing as much environmental variation as possible within a floristic province should be measured. This will ensure that a truer picture of Species Position Indices is obtained, according to species performance over a wide range of environmental conditions. Obviously then, a localized study, or one representing a narrow range of environmental variation, will not give results that are applicable to a larger area.

The data used in this paper suffer from certain deficiencies as they were originally collected for other purposes. As the mass collection method was not followed strictly, sampling deficiencies also occur. The aims, however, were to obtain preliminary information on the ecological status of major plant species in several veld types, to demonstrate the application and utility of Index Iteration under South African conditions, and to stimulate interest in the method. The inadequacies of the data are considered subordinate to these aims.

#### PROCEDURE

At each sampling site in the *Cymbopogon-Themedra* Veld and Bankenveld, 2,000 points were taken systematically by means of a wheel-point apparatus (Tidmarsh & Havenga, 1955) to determine the basal cover of grasses, other

herbs and small shrubs. Trees and large shrubs were relatively uncommon on the plains, and were not included in the present analysis. Eventually, all species qualifying for inclusion in these two sets of data turned out to be grasses, with the exception of two sedges grouped together as one attribute in the case of the Bankenveld.

Nearly all sampling sites were situated within the degree square  $26^{\circ}$  to  $27^{\circ}$  south and  $27^{\circ}$  to  $28^{\circ}$  east, roughly in the area between Potchefstroom and Johannesburg. A few sites fell north of this square. Sampling sites were located in the major vegetation type, within one-minute squares, irrespective of the successional stage to which the vegetation belonged, with the proviso that preference would be given to that part of the major vegetation type in best condition. The squares in which sampling sites were located were situated regularly along lines of longitude 15 minutes apart.

Wheel-point surveys were carried out at 52 sites. Only 33, which were deemed to be not unduly disturbed or unnatural, served as stands for the present study. Sixteen were in the *Cymbopogon-Themeda* Veld and 17 in the Bankenveld. The stands included appeared to be homogeneous, according to experienced observation, and were not tested statistically.

Basal cover percentages were converted to a relative base and used in lieu of Importance Values for all species qualifying for the analysis. All species with a presence greater than 56 and 53 per cent in the *Cymbopogon-Themeda* Veld and Bankenveld, respectively, and 33.3 per cent in the combined veld types, were included in the ordination studies.

The third set of data was collected initially for a stand ordination study (Morris, 1967). The study area was the conical hill, Ntshongweni, at the intersection of co-ordinates  $29^{\circ} 51'$  south and  $30^{\circ} 43'$  east. This hill is about 20 miles west of Durban, Natal, in the valley of the Mlazi River.

The basic sampling units were 60 quadrats of side 30.5 m, each subdivided into 16 square subsamples, the sampling units being located by a process of restricted randomisation. The raw data consisted of density and local frequency values for trees over one metre tall. Importance Values were calculated for the 29 species with frequencies of over 35 per cent in the 60 quadrats. Relative density (RD) and relative local frequency (RF) values for each species were calculated and Importance Values (IV) for species  $i$  in each quadrat were calculated as:

$$IV_i = 2 RD_i + RF_i$$

Twice as much weight was given to density than to frequency, because previous overseas work has indicated that density has a greater influence on Importance Values. Using the above procedure, the sum of the Importance Values for each stand is 300, but for future uniformity with other workers (see Goff & Cottam, 1967) it was scaled to 100.

The computer memory was not large enough to handle all 60 quadrats from the Valley Bushveld at the same time, so 20 quadrats from the south-facing slopes of the hill and 22 from the north-facing slopes were analysed separately.

A programme for Index Iteration, in Fortran IV, has been written for an IBM 1130 digital computer. Copies of the programme are available from the authors.

## RESULTS

The preliminary Species Position Indices, determined in the three veld types, are presented in Tables 1 and 2.

The position indices for species calculated from the combined data of the Bankenveld and the *Cymbopogon-Themedra* Veld differed quite considerably in value, but to a lesser extent in position, from those calculated for each veld

TABLE 1  
Preliminary Species Position Indices (SPI) for the western variation of the Bankenveld (B)  
and northern variation of the *Cymbopogon-Themedra* Veld (CT)

Species	SPI (nearest 0.5)		
	B + CT	B	CT
<i>Cymbopogon excavatus</i> . . . . .	3.5	—	1.0
<i>Andropogon amplexens</i> . . . . .	8.0	8.5	1.5
<i>Triraphis andropogonoides</i> . . . . .	4.0	1.5	—
<i>Aristida canescens</i> . . . . .	1.0	—	2.0
<i>Trachypogon spicatus</i> . . . . .	9.5	10.0	2.0
<i>Brachiaria serrata</i> . . . . .	6.5	6.0	2.5
<i>Eragrostis atherstonei</i> . . . . .	4.5	—	—
<i>Eustachys paspaloides</i> . . . . .	4.5	2.5	—
<i>Aristida congesta</i> . . . . .	4.0	1.0	3.0
<i>Cynodon dactylon</i> . . . . .	4.5	—	3.0
<i>Cymbopogon plurinodis</i> . . . . .	5.0	2.0	4.5
<i>Eragrostis racemosa</i> . . . . .	9.0	10.0	4.5
<i>Eragrostis chloromelas</i> & <i>E. curvula</i> . . . . .	6.5	6.0	5.0
<i>Bulbostylis</i> & <i>Fimbristylis spp.</i> . . . . .	—	5.0	—
<i>Digitaria eriantha var. stolonifera</i> . . . . .	6.5	5.0	—
<i>Tristachya rehmannii</i> . . . . .	7.0	5.5	—
<i>Setaria flabellata</i> . . . . .	8.0	8.0	6.5
<i>Andropogon schirensis</i> . . . . .	8.5	7.0	—
<i>Heteropogon contortus</i> . . . . .	9.0	9.0	7.0
<i>Elyonurus argenteus</i> . . . . .	9.0	9.5	8.5
<i>Digitaria tricholaenoides</i> . . . . .	10.0	10.0	—
<i>Themeda triandra</i> . . . . .	9.5	9.0	10.0

TABLE 2

Species Position Indices (SPI) for 20 quadrats on the south-facing slopes of Ntshongweni and 22 quadrats on the north-facing slopes

South-facing slopes species	SPI (nearest 0.5)	North-facing slopes species	SPI (nearest 0.5)
<i>Acalypha sonderiana</i>	10.0	<i>Canthium inerme</i>	10.0
<i>Dombeya tiliacea</i>	8.0	<i>Heteropyxis natalensis</i>	9.5
<i>Euphorbia tirucalli</i>	8.0	<i>Ziziphus mucronata</i>	9.5
<i>Grewia occidentalis</i>	7.5	<i>Acacia nilotica</i>	9.0
<i>Ochna arborea</i>	7.5	<i>Fagara capensis</i>	9.0
<i>Euclea natalensis</i>	7.5	<i>Cussonia spicata</i>	9.0
<i>Hippobromus pauciflorus</i>	7.5	<i>Acacia robusta</i>	8.5
<i>Canthium inerme</i>	7.0	<i>Rhus pentheri</i>	8.5
<i>Canthium mundianum</i>	7.0	<i>Acacia caffra</i>	8.5
<i>Ehretia rigida</i>	7.0	<i>Dichrostachys cinerea</i>	8.5
<i>Putterlickia verrucosa</i>	7.0	<i>Ochna arborea</i>	8.5
<i>Ziziphus mucronata</i>	7.0	<i>Putterlickia verrucosa</i>	8.5
<i>Fagara capensis</i>	7.0	<i>Dombeya rotundifolia</i>	8.5
<i>Brachylaena elliptica</i>	7.0	<i>Canthium mundianum</i>	8.5
<i>Cussonia spicata</i>	7.0	<i>Maytenus heterophylla</i>	8.5
<i>Euphorbia ingens</i>	7.0	<i>Xeromphis rudis</i>	8.0
<i>Acacia robusta</i>	7.0	<i>Aloe candelabrum</i>	7.5
<i>Heteropyxis natalensis</i>	6.5	<i>Commiphora caryifolia</i>	7.5
<i>Rhus pentheri</i>	6.5	<i>Euclea natalensis</i>	7.5
<i>Maytenus heterophylla</i>	6.5	<i>Euphorbia ingens</i>	7.5
<i>Spirostachys africana</i>	6.5	<i>Ehretia rigida</i>	7.0
<i>Combretum molle</i>	6.5	<i>Grewia occidentalis</i>	7.0
<i>Dichrostachys cinerea</i>	6.5	<i>Brachylaena elliptica</i>	7.0
<i>Dombeya rotundifolia</i>	6.5	<i>Combretum molle</i>	6.5
<i>Commiphora caryifolia</i>	6.5	<i>Hippobromus pauciflorus</i>	6.0
<i>Acacia caffra</i>	6.5	<i>Spirostachys africana</i>	5.5
<i>Acacia nilotica</i>	6.0	<i>Dombeya tiliacea</i>	5.5
<i>Xeromphis rudis</i>	5.5	<i>Acalypha sonderiana</i>	1.5
<i>Aloe candelabrum</i>	1.0	<i>Euphorbia tirucalli</i>	1.0

type separately. The separate treatment of veld types was favoured, in this case, for reasons mentioned in the discussion.

Some species from the Valley Bushveld had very low frequencies within one or other of the two quadrat groups, even though their frequencies over all 60 quadrats were high. For example, *Aloe candelabrum* occurred in only one of the 20 quadrats on the south-facing slopes but had an overall frequency of 48 per cent. Because one requirement for the calculation of SPI is that all species have reasonably high frequencies, the SPI values obtained in this manner

must be considered to be very tentative. It was not considered worthwhile reselecting those species with high frequencies in the two quadrat groups and then recomputing the Importance Values and SPI for the purpose of this preliminary paper.

The position indices of species which qualified for inclusion in the computations in the Bankenveld and the *Cymbopogon-Themeda* Veld were weighted by their Importance Values, thereby obtaining a Stand Synthetic Index for each stand. The usual procedure was followed, namely, multiplication of SPI by IV, and summation for the stand. When the Stand Synthetic Indices were compared with an independent subjective assessment of ecological status of stands, arrived at by allotting stands to three groups: low, medium and high status, the agreement was fairly good, particularly in the case of the Bankenveld (Table 3). Stand Synthetic Indices were not calculated for Ntshongweni because a stand ordination of all 60 quadrats had been carried out in a previous study (Morris, 1967). It was anticipated that very little additional information would be obtained by calculating SSI for 20 and 22 of the 60 quadrats separately.

TABLE 3  
Ecological status of stands ordinated from lowest to highest

Bankenveld			<i>Cymbopogon-Themeda</i> Veld		
Stand No.	SSI <sup>(1)</sup>	Subjective <sup>(2)</sup> assessment	Stand No.	SSI <sup>(1)</sup>	Subjective <sup>(2)</sup> assessment
12	73.0	L	16	61.0	L
6	76.8	L	24	68.1	L
17	81.6	L	22	70.3	M
21	82.6	M	20	71.1	M
15	84.1	L	28	71.6	L
9	84.8	M	18	72.2	L
8	84.9	M	33	74.0	M
7	85.3	M	23	74.9	M
14	85.6	L	19	75.1	M
11	86.4	M	27	76.8	H
10	87.8	M	31	76.8	H
3	88.7	H	25	76.9	M
4	89.3	H	29	78.6	M
5	89.1	H	26	79.4	M
13	90.9	M	30	80.7	H
1	91.5	H	32	82.9	H
2	92.1	H			

<sup>(1)</sup> Stand Synthetic Indices

<sup>(2)</sup> L = Low; M = medium; H = high ecological status



The results presented were obtained by processing the data in the species mode, i.e. Importance Values of species were compared with each other over all stands or quadrats, and the species ordered. Data may also be processed in the stand mode, i.e. Importance Values of species may be compared for stand pairs over all species and the stands ordinated (see Goff & Cottam, 1967). As the data were not specifically gathered for the type of work demonstrated here, and because good environmental data were not available, treatment of data in the stand mode was not carried out for the Bankenveld and *Cymbopogon-Themedra* Veld.

#### DISCUSSION

##### *Preliminary results*

The relative basal cover percentages in the stand by species matrices indicate that *Digitaria tricholaenoides*, *Tristachya rehmannii*, *Triraphis andropogonoides*, *Andropogon schirensis*, *A. amplexans*, *Trachypogon spicatus*, *Eragrostis racemosa* and *Brachiaria serrata* are far more frequent and important in the Bankenveld than in the *Cymbopogon-Themedra* Veld. They are not entirely excluded from the latter (with the possible exception of the first species), but are largely confined to stony outcrops. There are many indications that the Bankenveld has a lower ecological status than the *Cymbopogon-Themedra* Veld. This is implied also by Louw (1951).

In the absence of a specifically planned, and more intensive study, it would be unwise to be dogmatic about the order of ecological status obtained for the species listed in the tables. In general, they conform to what would be expected from field experience. There are a few anomalies. *Cymbopogon* spp. appear to be placed lower than would be expected. Louw (1951, p. 57) rated *Cymbopogon* spp. as occurring high in the plant succession, following on *Themeda triandra*-dominated grassland. Bews (1918) thought the same, saying that they belonged to a stage transitional to forest or else to the hydrosere. Grunow (1965) considered *C. plurinodis* to be a species occurring more frequently in mesophytic than xerophytic or hydrophytic conditions. It is possible that factors like burning or grazing, considered natural in South Africa, would maintain *Cymbopogon* spp. at a lower level of importance than would be expected from uninhibited competition. It is inherent in Index Iteration and similar methods of ordination that under these circumstances the gradient placement of these species would be lowered.

The placement of most other species seems to be borne out by the successional placement mentioned in the literature. The following grasses and sedges are placed in the initial grassland stages as pioneers: *Aristida congesta*, and *Aristidas* in general, *Cynodon dactylon*, *Eragrostis chloromelas* and other species (Bews, 1918; Adamson, 1938; Louw, 1951; Bayer, 1955), *Bulbostylis* spp. and

*Eustachys paspaloides* (Bews, 1918). The following grasses are placed in stable grassland as climax grasses or their associates: *Themeda triandra* (Bews, 1918; Adamson, 1938; Louw, 1951; Bayer, 1955), *Elyonurus argenteus* (previous authors and Rose Innes, quoted by Roux, 1954), *Andropogon amplexans*, *A. schirensis*, *Brachiaria serrata*, *Digitaria eriantha*, *D. tricholaenoides*, *Setaria perennis* (and presumably also *S. flabellata*), *Heteropogon contortus* (Bews, 1918), *Trachypogon spicatus* (Rose Innes, quoted by Roux, 1954; Davidson, 1964; Edwards, 1967). Thus, at least the primary separation of pioneer from climax species (low ecological status from high ecological status) is achieved by Index Iteration.

Owing to the computer limitations mentioned previously, the SPI obtained for the Valley Bushveld must be considered very tentative. If the species with low frequencies (e.g. *Aloe candelabrum* on the south-facing slopes) had been omitted, a more useful ordering would possibly have resulted.

The environmental factors affecting SPI on the south-facing slopes are not clear. *Acalypha sonderiana* and *Euphorbia tirucalli*, with high SPI and *Aloe candelabrum* with the lowest SPI are considered to be species with low ecological status. All three are characteristic of dry, shallow soils (see Bews, 1917). *Aloe candelabrum* is a leaf succulent and *Euphorbia tirucalli* a stem succulent of very dry regions (see also Edwards, 1967). However, *Dombeya tiliacea*, *Grewia occidentalis*, *Euclea natalensis* and *Hippobromus pauciflorus* are considered by the authors, and supported by Edwards (1967), to be species of high ecological status, being either locally mesic, stream-bank or forest precursor species. The Species Position Indices on the south-facing slopes are thus difficult to interpret. Species which are considered to have high ecological status are placed next to species which have low status while species at both ends of the axis have low ecological status.

An order which is much easier to interpret and is more informative resulted from analysing 22 quadrats from the north-facing slopes of Ntshongweni. The two species with the lowest SPI are *Acalypha sonderiana* and *Euphorbia tirucalli*. As mentioned above, these species are considered to have low ecological status. The large SPI hiatus between these two species and the others indicates how different they are from the others with respect to ecological status. According to Edwards (1967) and the present authors, the following species, which have high SPI, have high ecological status: *Canthium inerme*, *Heteropyxis natalensis*, *Ziziphus mucronata*, *Fagara capensis* and *Acacia robusta*. Bews (1917) also considered *Ziziphus mucronata* to have a high ecological status. Species with low ecological status, according to Edwards (1967) and the present authors, which have SPI of less than 8.0 include: *Aloe candelabrum*, *Euphorbia ingens*, *Brachylaena elliptica*, *Combretum molle* and *Spirostachys africana*. The last-

mentioned species inhabits the very dry bottom of the Tugela Valley (Edwards, 1967). According to the present analysis and Bews (1917), *Ehretia rigida* is accorded low ecological status.

A subjective ordering of these species would alter the positions of some species. *Hippobromus pauciflorus* and *Grewia occidentalis* would be attributed higher ecological status and *Aloe candelabrum* a lower status. Apart from these and a few other discrepancies, agreement between computed SPI and ordering based on field experience is good.

It was also pointed out by Dr. D. Edwards (pers. comm.) that the ordination separates species of base-rich soils from those favouring base-poor soils. Species favouring base-rich soils are *Euphorbia tirucalli*, *Acalypha sonderiana*, *Spirostachys africana*, *Brachylaena elliptica*, *Ehretia rigida* (possibly), *Euphorbia ingens* and *Rhus pentheri*. On the north-facing slopes all these species, with the exception of the last-mentioned species, have low ecological status. Conversely, species favouring base-poor soils have high SPI.

The relationship of SPI to moisture conditions and base-status of the soil discussed above, are only two of the many interrelationships which affect the ordering of species by Index Iteration. The final positioning is the result of averaging out all the relationships. The ordering of species on the south-facing slopes may be difficult to interpret because the gradients oppose one another whereas the major gradients on the north-facing slopes are acting in harmony.

### General

Curtis (1959, p. 16; quoting Cain) states that, "the significance of floristic provinces in the study of regional vegetation lies in their influence on the possible floristic composition of the individual communities". It would be unrealistic to expect species of the Boreal element to occur in southwest Wisconsin, because they do not occur anywhere in this area. On the other hand, practically all members of the Prairie and Alleghenian elements do. Any stand of vegetation can, therefore, be taken to have had an equal chance of receiving propagules of all those species. The fact that they have sorted themselves into different combinations must be due to varied historical and environmental factors. Floristic provinces are usually delimited by mapping the distribution ranges of principal species, preferably in conjunction with a knowledge of their abundance at the places for which there is a record (Curtis, 1959).

In Wisconsin, the floristic provinces distinguished correspond with climatic differences. In South Africa, geologic and soil factors, in addition, are often major environmental determinants of plant distribution patterns. In fact, the western variation of the Bankenveld was observed by one of us (J.O.G.) to coincide, within very narrow limits, with the Dolomitic Series of the Trans-

vaal Geological System, while the northern variation of the *Cymbopogon-Themeda* Veld occurs on the Pretoria series of the same system in this area. The latter veld type occurs widely, however, and is certainly not as specific for soil type as the former appears to be.

Many species show marked differences of abundance in the two veld types mentioned above. The occurrence of other species appears to be largely limited to one or other veld type. For this reason, it seems best to treat each as a floristic province separated from the other on the basis of marked soil discontinuities. Separation does not appear justified on climatic grounds, neither do they differ sufficiently to be separated according to floristic origin as both veld types are composed largely of tropical element species of the South African flora.

Although the considerations in defining floristic provinces may seem to be somewhat nebulous, it will probably not be so in practice. Species distributions of relatively large aerial extent are generally fairly readily separable from small ones, whether they be caused by climatic or soil discontinuities. To the authors, it appears that Acocks's (1953) veld types, with some exceptions, may serve satisfactorily as floristic provinces in ordination studies. Some veld types may have to be split, while specific cases come to mind where two or three may be grouped together advantageously. It will undoubtedly be better to process data from an area smaller than the full extent of a floristic province if there is a danger of exceeding the boundary, provided that an adequate range of geographic and other variation is included in the sample. The data collected at Ntshongweni excluded geographic, if not other variation, and cannot be considered representative of the whole Valley Bushveld.

It must be emphasized that Species Position Indices do not necessarily reflect position along the moisture gradient, although this has often been found to be the case. Some other soil factor, for example, may set a limit to the importance which a species can achieve under natural competitive conditions over the whole extent of the floristic province, thereby resulting in a low Species Position Index, or even excluding the species entirely.

The results published in this paper are tentative and applicable only to the variations of veld types mentioned because the data did not come from a wide enough geographic or environmental range of variation. They may be found useful, however, for assessing veld condition trends in the localities concerned. Basal cover data, which are often available for the herbaceous stratum, may be placed on a relative basis and the Stand Synthetic Indices calculated (see Table 3), at intervals of a few years. This will indicate whether the stands concerned are changing to less favourable or more favourable ecological conditions.



## ACKNOWLEDGEMENT

Dr. D. Edwards, of the Botanical Research Institute, is thanked for fruitful discussion and constructive criticism. His intimate field knowledge of the species of the Valley Bushveld, in particular, was of great assistance to the authors in interpreting the results.

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## EUPHORBIA SPECIES FROM THE FLORA ZAMBESIACA AREA: VIII†

L. C. LEACH

In 1965 Dr. Graham Williamson of Lusaka sent me a live plant of a succulent *Euphorbia* from the Kabompo Gorge in NW Zambia, which appeared to be new to the Flora Zambesiaca area. Later that year he sent flowering material preserved in liquid; although much damaged by caterpillars it was possible to confirm from this that it was not previously known from Zambia and that it was closely related to *Euphorbia sereti* De Wild.

The following year, the author, conducted by Dr. Williamson, visited the Kabompo Gorge and good flowering and fruiting material was obtained; examination of this and of the type of *E. sereti* confirmed their close relationship.

However, other related plants from Angola and elsewhere in Zambia became involved and a decision regarding the taxonomic position was held over until these could be investigated. This finally became possible when good material of the new species from Kawambwa, N. Zambia, was collected by Dr. Williamson and Mr. B. Simon of the Government Herbarium, Salisbury.

*E. sereti* is not well known, it is thought therefore, that although from outside the Flora Zambesiaca area, the amplified description included in the following notes will not be out of place.

***Euphorbia sereti*** De Wildeman, in Ann. Mus. Congo, Sér. V, 2: 290 (1908).—N. E. Brown in Fl. Trop. Afr. 6, 1: 603 (1912).—Type: Congo, *Seret* 466 (BR!).

This interesting species is one of a group of closely related but spatially isolated relic populations, in most of which all the cyathia of the inflorescence are bisexual, an unusual character in this genus.

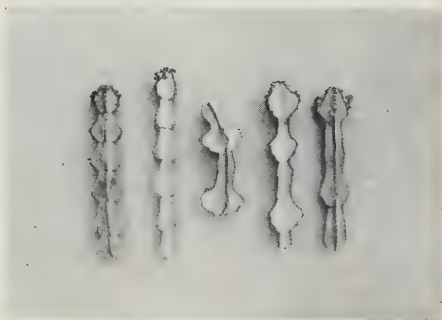
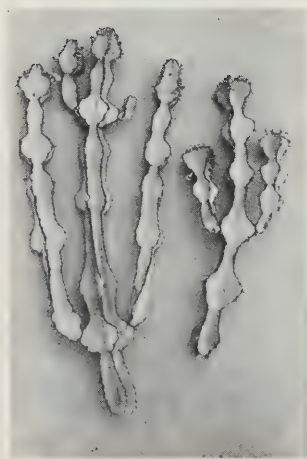
Divergence between most of these populations is such that recognition at specific level seems to be the logical course but in the present instance the differences between the two populations involved seem to be more a matter of tendencies rather than of clear cut divergent characters; this seems to indicate sub-specific status as being the logical interpretation of the taxonomic situation.

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† Accepted for publication 4th June, 1968.



Dr. G. Williamson with plants at Kabompo Gorge.



Variation in branch segments.

*Euphorbia sereti* De Wildeman subsp. *variantissima* Leach

Congo.—Orientale Prov., Ngoa, 25 Km. E, Gombari, fr. 17. i. 1906, *Seret* 466 (BR); inter Faradje et Dungu, fl. viii. 1931, *Lebrun* 3455 (BR).

The author was unable to locate Seret's locality, "Roches de N'goi à six heures de Gumbari", on the maps available, but from information supplied by Dr. L. Liben, it appears that Seret's Gumbari is, in fact, Gombari (c. 2° 45' N, 29° 03' E), while Ngoa, about 25 km. to the east, would correspond well with "à six heures de Gumbari".

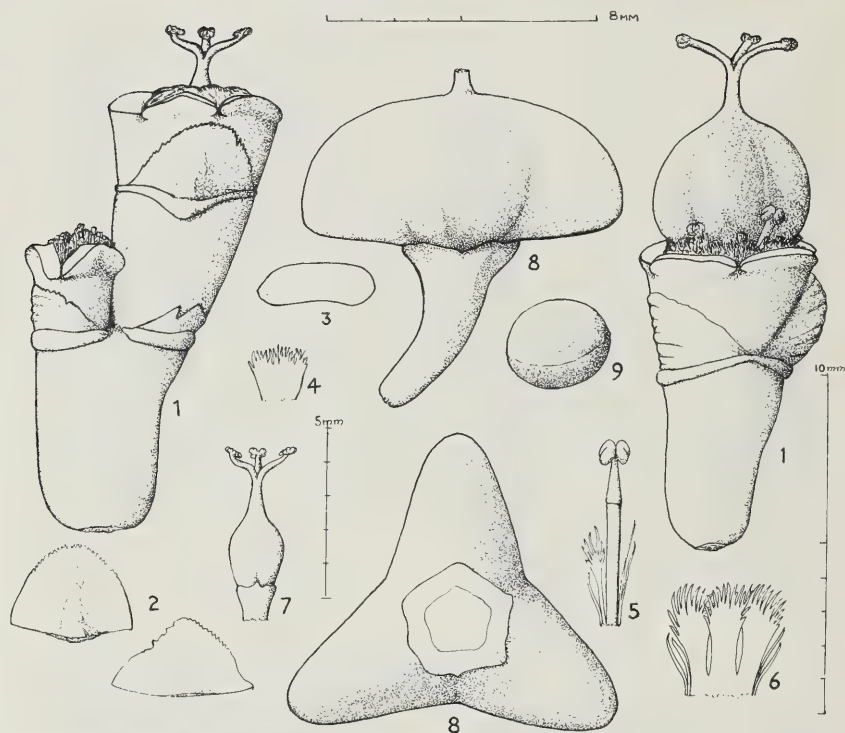
*Plant* candelabriform,  $\pm$  1.5 m high, with segmented, 4—5-winged, spiny branches, with the wings a little more than 2 cm wide at their widest. *Segments* subcircular or ovate, 5—7 cm long, slightly crenulate on the continuous horny margins which are considerably widened at the flowering eye. *Spines* in horizontally spreading pairs 2—11 mm long, longest at the widest part of the wings. Leaves often marcescent, when deciduous leaving an inconspicuous scar, with or without shrivelled rudimentary prickles. *Inflorescence* 1—3 pedunculate cymes, with the initial cyathium bisexual, lateral cyathia developed only sparingly and then usually only in the adaxial position. *Peduncle* bibracteate, slightly scabrid, 1.5—6 mm long; *bracts* with a finely denticulate margin, c. 3 mm wide, 1.5 mm long, with a prominent transverse basal ridge. *Cyme branches* generally shorter than the peduncle. *Involucre* c. 2.5 mm long; *glands* 5, transversely elliptic c. 3 mm wide, probably microscopically tuberculate when alive, rugulose when dry; *lobes* 5, fimbriate-dentate, sometimes somewhat emarginate, subquadrate, c. 1.5 mm wide. *Male flowers* c. 30 (with up to 8 in one fascicle), arranged in 5 fascicles each subtended by a broad fimbriate laciniate bract. *Pedicels* c. 2.5 mm long. *Capsule* exserted, 3-lobed, c. 8—9 mm diam., 5 mm high. *Seed* subglobose, c. 2.5 mm diam., brownish cream, minutely dotted with purple brown.

The foregoing description is based partly on De Wildeman's original description and partly on a critical examination of the type material as well as that of *Lebrun* 3455.

Subsp. **variantissima** Leach, subsp. nov.

A subspecie typica statura altiore; ramorum segmentis constrictione angulata vix alata usque ad 10 cm longa saepissime separatis; bracteis grandioribus; spinis obsolescentibus; pedunculis et cymarum ramis longioribus glandulis transverse oblongis laevibus margine leviter incrassato; floribus masculis plerumque valde exsertis; capsula et semine ambobus aliquantum grandioribus divergens.

*Frutex* succulentus spinosus candelabriformis, ad 3 m altus, basiramifer vel arboreus, trunco brevi crasso cylindrico. *Rami* erecti vel arcuato-erecti, plerum-



*Euphorbia serefi* subsp. *variantissima*

- |                      |                              |             |
|----------------------|------------------------------|-------------|
| (1) Inflorescence    | (4) Involucral lobe          | (7) Ovary   |
| (2) Bract            | (5) Male flower & bracteoles | (8) Capsule |
| (3) Involucral gland | (6) Fascicular bract         | (9) Seed    |

que simplices usque ad 1.6 m longi, 3—6-alati (plerumque 4—5, raro 6), in segmenta variantissima constricti, segmentis plerumque subcircularibus, tunc c. 6 cm longis latisque, constrictione angulata vix alata, ad 10 cm longa saepissime separatis; margine continuo corneo crenulato, initio rufescenti mox nigrescenti suberescenti; rami secundarii ramulisque alarum ex marginibus exorti, initio 3-alati, mox ala quarta et interdum quinta evoluta; ramuli terminales plerumque 3-alati. *Spinae* binae, divergentes, 1.5—8 mm longae, saepe celeriter obsolescentes, in constrictionibus saepissime obsoletae. *Folia* exigua, mox decidua, cicatrice obscura, spinula carnosa patula in quoque latere plerumque instructa. *Inflorescentia* cymosa, basi spinulis binis plerumque in-

structa; *cymae* 1—5, pedunculatae, horizontaliter dispositae; unaquaeque cyathii 1—3, omnibus bisexualibus, cyathia lateralia parce effecta, plerumque cyathio unico adaxialiter sito. *Pedunculus* 2—9 mm longus, basi c. 3 mm diam. leviter lateraliter compressus, versus apicem auctus ad 4·5 mm diam., scabrellus bibracteatus; *bracteae* 3·5—5 mm latae, 2—3 mm longae, plerumque minute denticulatae, saepe protentae scissae, basi prominenter transverse porcatae; *cymarum ramis* pedunculo similes sed plerumque breviores. *Involucrum* cyathiforme, c. 3—3·5 mm longum, plerumque c. 5 mm diam., aliquando ubi glandulis patulis ad 7·5 mm diam.; *glandulae* 5—6 (plerumque 5), transverse oblongae, 2·5—3·5 mm latae, suberectae (raro patulae) concavae laeves carnosae flavae integrae, margine leviter incrassato laevissimo circumdanti; *lobi* 5—6, fimbriato-dentati, subquadrati c. 1·5 mm lati leviter carinati. *Flores masculi* c. 40, bracteolis variantibus numerosis, saepe ex involucrio ad 3 mm exserti, 5—6 fasciculati; *bracteae* fasciculares latae laciniato-fimbriatae; pedicelli ad 3·5 mm longi; filamenta c. 1·25 mm longa. *Ovarium* plus minusve obovoideum, initio breviter stipitatum perianthio rudimentali ex involucrio mox exsertum; ovulum sub cucullo parvulo dependenti. *Styli* crassi, usque ad 3 mm longi, 1/3—1/2 in columnam connati partibus libris patulis, apicibus capitatis rugulosis. *Capsula* profunde tri-lobata, c. 9·5 mm lata, 4·5 mm alta, ex involucrio exserta pedicello crasso ad 7 mm longo, perianthio rudimentali aliquantum obscure pentagono. *Semen* fere maturum, brunneum vel ex olivaceo brunneum maculosum, obscure rugulosum vel laeve, subglobosum, c.  $3 \times 2\cdot6$  mm.

Type: *L. C. Leach & G. Williamson* 13551 (B; BM; BR; G; K; LISC; LUA; LUAI; NDO; PRE; SRGH, holotypus; ZSS).

ZAMBIA. N.W. Province, Kabompo Gorge, c. 12° 6' S, 25° 8' E, alt. c. 3500', fl. Oct. 1965, *G. Williamson* s.n. in *Leach* 13167 (PRE; SRGH); *ibid.* fl. & fr. 25. x. 1966, *Leach & Williamson* 13551 (Herbaria as above).

The subspecific epithet is indicative of the degree of variability of the Kabompo Gorge population. It is in the shape of the segments and the presence or absence of long constricted portions of the branches that the greatest variations occur (see photographs) in these characters the new taxon varies to a greater extent than any other known to the author.

Its taller stature and the tendency to develop elongated constrictions most obviously distinguish this subsp. from the typical, but there are several other less noticeable differences; the bracts of subsp. *variantissima* are larger, as also are both capsule and seed, while the glands of the involucre are smooth with a slightly thickened margin; there is also a tendency for peduncles and cyme branches to be longer and for the male flowers to be more exserted from the involucre.



Basically the inflorescence consists of 1—3 pedunculate cymes (often reduced to a single bisexual cyathium) but there are several variations of this pattern. There may be up to 5 peduncles, produced simultaneously or sometimes successively; lateral cyathia are somewhat sparingly developed (when one only this seems always to be adaxial) and also often develop successively. Sometimes a branch may bear cymes which are all at more or less the same stage of development, while another on the same plant may have the lower cymes with capsules already dehiscent and those near the apex still in bud.

The latex of *E. sereti* was stated by Seret to be "très corrosif" but that of the Zambian subsp., smelling, as it does, faintly and not unpleasantly of tobacco seems to lack these corrosive qualities. However, it has been observed that the acidity of the latex seems to vary considerably within a species (whether with season or some other factor has not, unfortunately, been determined), this may, therefore, be of little significance.

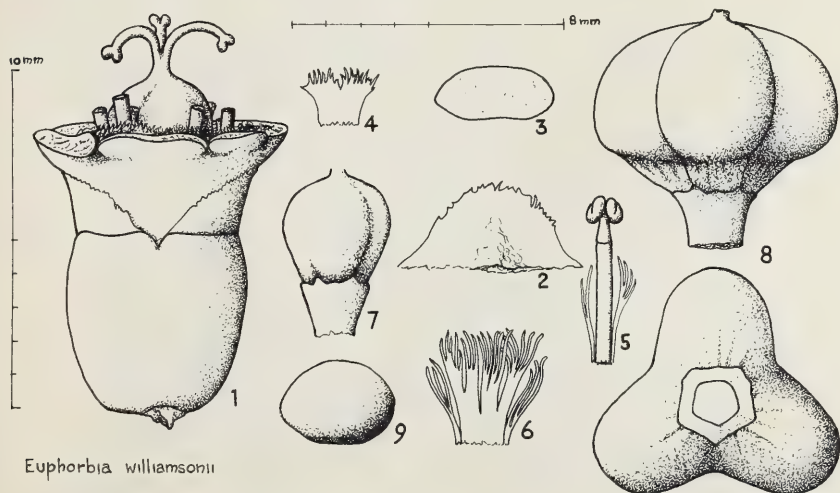
This isolated population appears to be particularly subject to attack by small caterpillars, with the result that few cyathia reach maturity.

*Plant*, a candelabriform succulent spiny shrub up to 3 m high, branching from the base or tree-like with a short, stout, gnarled cylindric trunk up to 22.5 cm thick, exceptionally up to 1.3 m high. *Branches* erect or arcuate-erect, mostly simple, up to 1.6 m long, 3—6 winged (usually 4—5, rarely 6), constricted into segments of varying shape, mostly subcircular, generally about 6 cm wide and long, with a continuous crenulate horny margin, red-brown at first but together with the spines rapidly degenerating and becoming blackish and corky; the segments very frequently separated by angular scarcely winged constricted portions less than 2 cm diam. and up to 10 cm long. Secondary branches and branchlets, when present, arising from the margins at the widest part of the wings, initially 3-angled, soon developing a fourth and sometimes a fifth, terminal branchlets usually 3-angled. *Leaves* fleshy, acute, vestigial, soon deciduous leaving an obscure scar flanked by a pair of quickly obsolescent spreading fleshy prickles. *Inflorescence*: 1—5 horizontally arranged pedunculate cymes of 1—3 cyathia, from the flowering eye which is usually flanked by a pair of prickles. *Cyathia* all bisexual, laterals sparingly produced, most frequently in the adaxial position only. *Peduncle* 2—9 mm long, c. 3 mm diam. at the base, somewhat laterally compressed, enlarging towards the apex, up to 4.5 mm diam., minutely scabrid with raised whitish flecks, bibracteate; *bracts* 3.5—5 mm wide, 2—3 mm long, usually minutely denticulate, often stretched and split, with a prominent, persistent, brown, transverse basal ridge; cyme branches similar to the peduncle but generally shorter. *Involucre* cup-shaped, c. 3—3.5 mm long, generally c. 5 mm diam., occasionally, when glands are spreading, up to 7.5 mm diam.; *glands* 5—6 (usually 5), transversely oblong, 2.5—3.5 mm wide, suberect (rarely

spreading) concave, smooth with a slightly thickened smoother margin all round, entire, fleshy, yellow; lobes 5—6, fimbriate dentate, subquadrate c. 1·5 mm wide, slightly keeled. *Male flowers* c. 40, often exserted up to 3 mm from the involucre, arranged in 5—6 fascicles, each subtended by a broad lacinate fimbriate bract, with numerous variably filiform fimbriate bracteoles; *pedicels* up to c. 3·5 mm long; *filaments* c. 1·25 mm long. *Ovary* more or less obovoid, shortly stipitate with a rudimentary perianth, soon exserted from the involucre; ovule suspended under a minutely denticulate hood. *Styles* stout, up to 3 mm long, 1/3 to 1/2 united into a stout column, the free portions spreading, with the capitate rugulose apices turned upward, later becoming more reflexed. *Capsule* deeply 3-lobed, c. 9·5 mm broad, 4·5 mm high, exserted from the involucre on a stout pedicel up to 7 mm long, with a somewhat obscurely pentagonal rudimentary perianth. *Seed* (almost mature), brown or mottled olive brown, obscurely rugulose or smooth, subglobose, c. 3 × 2·6 mm.

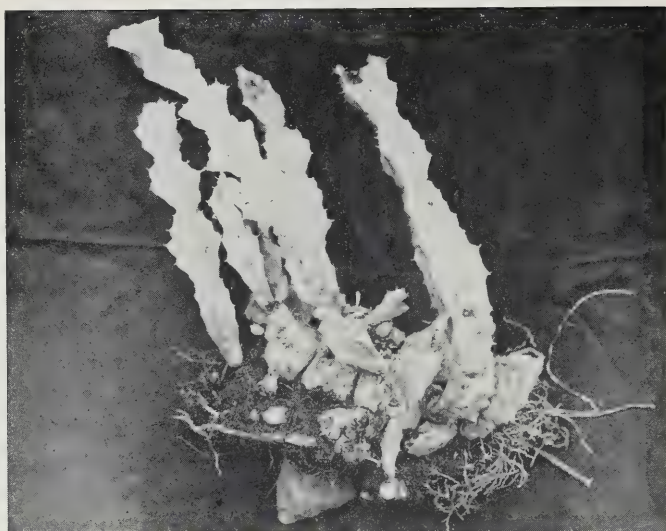
***Euphorbia williamsonii* Leach, sp. nov.**

*E. atrocarmesinae* Leach affinis sed planta parviore, caulorhiza tuberosa partialiter epigena; ramis 3-angulatis, segmentorum forma; podariis separatis vel subcontinuis; involucre parviore; ovario breviter pedicellato obovato; capsula coccineo-nitida facile distinguenda.

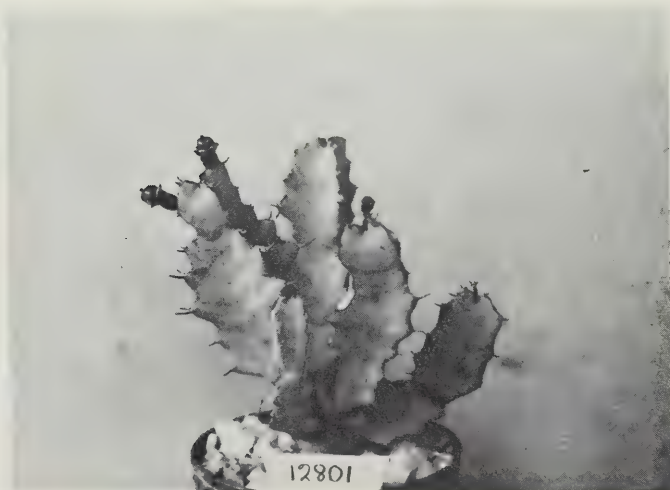


*Euphorbia williamsonii*

- |                      |                              |             |
|----------------------|------------------------------|-------------|
| (1) Inflorescence    | (4) Involucral lobe          | (7) Ovary   |
| (2) Bract            | (5) Male flower & bracteoles | (8) Capsule |
| (3) Involucral gland | (6) Fascicular bract         | (9) Seed    |



Plant from Ntumbachushi Falls, c. 30 cm high, with partially exposed irregularly tuberous caudex.



Young plant in cultivation at Nelspruit, c. 10 cm high, shewing solitary cyathia.

*Euphorbia williamsonii* Leach

*Frutex* spinosus succulentus, usque ad 1 m altus, ramis ex caulorhiza tuberosa fortuito exortis. *Caulorhiza* magna, irregulariter tuberosa partialiter epigena, radicibus crassiusculis fibrosis duriusculis numerosis congestis instructa. *Rami* saepissime simplices, erecti, 3-angulati, in segmenta leviter constricti; ramuli raro praesentes, tum brevissimi segmentorum ex marginibus emissi; *segmenta* oblonga vel subcirculares vel interdum aliquantum obtrullata, 2·5—5·25 cm lata, 2·5—5 cm longa, faciebus planis vel perleviter concavis, margine crenulato. *Podaria* plus minusve obovata decurrentia, supra producta gemmam includentia, quandoque confluentia marginem subcontinuum formantia. *Spinae* binae divergentes, ad 10 mm longae, saepe leviter curvae, ad 18 mm secus angulos distantes. *Folia* ovata, acuta, c. 1·5 mm lata, 2 mm longa, mox decidua, cicatrice indistincta, spinulis binis rudimentales basi instructa, *Inflorescentia* axillaris, saepissime spinulis rudimentales basi instructa, pedunculis 1—3, horizontaliter dispositis, unusquisque cyathio unico bisexuali praeditus. *Pedunculus* bibracteatus, 1·5—5·5 mm longus, usque ad 5·75 mm diam., plus minusve doliiformis, plerumque minute scabrellus, coccineus. *Bracteae* atro-coccineae semicirculares leviter obtuse caperato-carinatae, irregulariter denticulatae vel erosae, c. 5·5 mm latae, 2·5 mm longae, facile separatae. *Involucrum* 5—7 mm diam. glandulis inclusis, usque ad 3 mm longum, extus coccineum saepe minute sparse scabrellum; *glandulae* 5—6 (plerumque 5), leviter contiguae, plus minusve transverse ellipticae, 2·5—4 × 1·5 mm, patulae, leviter concavae vel convexae, minute puncticulatae (in sicco rugulosae), viridi-luteae; *lobi* 5—6, transverse oblongi, 2—2·5 mm lati, 1·5 mm longi, fimbriati, saturato-coccinei. *Flores masculi* c. 60, bracteolis filiformibus numerosis, 5—6 fasciculati; bracteae fasciculares laciniato-fimbriatae, latae, ad 3·5 mm longae; *pedicelli* usque ad 3·5 mm longi; *filamenta* c. 1 mm longa. *Ovarium* breviter stipitatum, mox partim exsertum, plus minusve obovoideum, trilobatum. *Styli* crassi, 2·5—3 mm longi, patuli reflexique, e basi in columnam crassam breviter connati, apicibus capitatis emarginatis rugulosi. *Capsula* coccinea, nitida, rotundato-trilobata basi aliquantum contracta, usque ad 9·5 mm lata, 5·5 mm alta, ex involucrio fere exserta pedicello brevi crasso et perianthio rudimentali, obscure pentagono, c. 3·5 mm diam. *Semen* (fere maturum) laeve, brunneum, subglobosum, c. 3 × 3·5 mm.

Type: *G. Williamson & B. Simon* 729 (PRE, SRGH, holotypus).

ZAMBIA. Northern Province, Kawambwa, "savanna by falls" fl. 13. xi. 1957, *Fanshawe* 4080 (NDO); ± 10 mls. W of Kawambwa, Ntumbachushi Falls, c. 9° 52' S, 28° 55' E, "Growing in fibrous mats on rocky quartzite outcrop", fl. & fr. 22. xii. 1967, *Williamson & Simon* 729 (PRE; SRGH); *ibid.* cult. Nelspruit, fl. 6. iii. 1968, *A. W. Dock* s.n. in *Leach* 12801 (K).



*E. williamsonii* seems to be most closely related to *E. atrocarnesina* but differs in being a smaller plant with 3-angled branches arising from a partially exposed irregularly tuberous caudex; the branch segments are also differently shaped while the spine shields are separate or only occasionally form a sub-continuous margin; the smaller involucre and shiny red capsule are very different from those of its relative as is also the shortly stipitate obovoid ovary.

In 3-angled branches and tuberous caudex there is also a relationship with *E. buruana* Pax, from Kenya, and herbarium specimens of the two species do superficially closely resemble each other. However, apart from numerous differences of detail, the inflorescence of Pax' species is entirely different, being of the more usual pattern with cymes of 3 cyathia, of which the central is male deciduous.

The new species is known only from the type locality on a quartzite outcrop on the north bank of the river in the vicinity of Ntumbachushi Falls, some 10 miles west of Kawambwa.

*Plant* a spiny succulent small shrub, up to 1 m high, acaulescent, with numerous branches arising at random from an irregularly shaped, partially exposed, somewhat tuberous caudex bearing a congested mass of hard fibrous roots. *Branches* erect, 3-angled, generally simple, slightly constricted into somewhat variably shaped segments; *segments* more or less oblong, subcircular or somewhat obtusate, about 2.5—5.25 cm wide across the face, 2.5—5 cm long, with the faces flat or slightly concave; branchlets seldom present, then very short, produced from the margins of the segments towards the apex of the branches. *Spine shields* more or less obovate, decurrent below, extended above to include the flowering eye, separate or occasionally forming a subcontinuous crenulate horny margin. *Spines* in diverging pairs, up to 10 mm long, often slightly up-curved, up to 18 mm apart along the angles. *Leaves* ovate acute, c. 1.5 mm wide, 2 mm long, soon deciduous, leaving an indistinct scar with a pair of rapidly deteriorating rudimentary prickles. *Inflorescence* axillary, often with rudimentary prickles at its base, cyathia 1—3, bisexual, pedunculate, horizontally arranged. *Peduncle* bibracteate, 1.5—5.5 mm long, up to 5.75 mm diam., more or less barrel shaped, minutely scabridulous. *Bracts* dark, almost blackish red, more or less semicircular with a slight wrinkled keel, irregularly denticulate or erose, easily detached from the narrow inconspicuous basal ridge, c. 5.5 mm wide, 2.5 mm long. *Involucre* 5—7 mm diam. including the glands, up to 3 mm long, often sparsely minutely scabridulous, bright red; *glands* 5—6 (mostly 5), contiguous but not very closely so, more or less transversely elliptic, 2.5—4 × 1.5 mm, spreading, slightly concave or convex (depending on the development of the capsule), minutely punctulate (rugulose when dry), greenish orange-yellow, tinged red on the smooth rounded margin; *lobes* 5—6, fimbriate, trans-



versely oblong, 2—2.5 mm wide, 1.5 mm long, dark red. *Male flowers*  $\pm$  60, with numerous filiform bracteoles, arranged in 5—6 unequal fascicles, each subtended by a broad lacinate fimbriate bract up to 3.5 mm long; *pedicels* up to 3.5 mm long; *filaments* c. 1 mm long. *Ovary* shortly stipitate, soon partly exserted, more or less obovoid, 3-lobed; ovule suspended under a small, minutely fringed hood. *Styles* stout, 2.5—3 mm long, spreading recurved, shortly united at the base into a stout column, with capitate emarginate apices. Capsule obtusely 3-lobed, somewhat contracted at the base, shining bright red, up to 9.5 mm diam., 5.5 mm high, not completely exserted from the involucre, with a short stout pedicel and a rudimentary obscurely pentagonal perianth. *Seed* (almost mature) smooth, brown, subglobose, c.  $3.5 \times 3$  mm.

#### ACKNOWLEDGEMENTS

The author is much indebted to:

The Directors of the Jardin Botanique de l'Etat, Bruxelles (BR) and the Forest Research Herbarium, Kitwe, Zambia (NDO), for the loan of material.

Mr. A. W. Dock of Luanshya, for a living plant of *Euphorbia williamsonii*.

The Chief, Botanical Research Institute, Pretoria (PRE) and the Chief Botanist, Government Herbarium, Salisbury (SRGH), for the facilities of the herbaria.

Dr. Graham Williamson, in whose honour the new species from Kawambwa is now named, for many gatherings of material and photographs of *Euphorbieae* which have been of considerable value to me, and for hospitality when the Kabompo Gorge and other localities in Zambia were visited.



### THREE NEW SPECIES AND A NEW VARIETY OF ERICA †

H. A. BAKER

#### ABSTRACT

Descriptions are given of two *Erica* species not hitherto described, of one recently discovered and of a new variety of *E. colorans* Andr. Additional notes giving distributional information about two species previously described by the author are included.

***Erica inordinata*** H. A. Baker sp. nov. (Ericaceae-Ericoideae) Evanthé.

Frutex erectus robustus parce ramosus ad 1·2 m altus. *Rami* ramulis numerosis, brevibus, effusis, pubescentibus et pilis longioribus villosibus admixtis. *Folia* 3-nata, 1·5—3·0 mm longa, erecto-patentia, imbricata, linearia ad oblonga, acutata, plus minusve supra concava, infra rotundata, sulcata, hispidulissima, sparsum ciliata seteris glandulosis. *Flores* terminales solitarii, plus minusve fasciculati, pro parte extrema ramulorum; pedunculati pro parte maxima circa 5 mm, sed interdum ad 10 mm longi, glandulosi, viscidi; bracteae remotae, parvae, varians, subovatae, glanduloso-ciliatae. *Sepala* 3—6 mm longa, aliquantum effusa, ovata, concava, cartilaginea, 12-nervata, glabra, viscida, marginibus plus minusve involutis, glandulosis, rubra, tandem straminea. *Corolla* valde variabilis, primo anguste tubularis, alba ad apicem rosea, basi plus minusve inflatescens; tubus latescens, circa antheras tumidus, fauci angustatus, asymmetrica, 13—25 mm longa, plerumque circa 13 mm, glabra, viscidissima, rubra vel vido-coccinea; lobis circa 2 mm longis, leviter effusis, obtusis, brunescens. *Filamenta* gracilia; antherae inclusae, 2 mm longae, anguste oblongae, laterales, bipartitae, basi scabrae, plus minusve cohaerens; aristis basi recurvatis, asperis, pallidis, fere pars tertia lobi; poro fere pars quarta lobi. *Ovarium* late turbinatum, glabrum; stylo exserto; stigmatibus capitellato.

Erect robust shrub, rather sparingly branched to about 4 ft. *Branches* with numerous short, spreading branchlets, pubescent and villous, glabrescent. *Leaves* 3-nate, 1·5—3·0 mm mostly 2 mm long, erect-spreading, imbricate, variable in shape from linear to oblong, acute, somewhat concave above and rounded below, sulcate, minutely hispidulous, sparsely glandular-setose-ciliate. *Flowers* solitary, terminal on short branchlets and clustered into a pseudo-raceme at or near the ends of the branches; peduncles mostly 5 but up to 10

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† Accepted for publication 30th October, 1968,



PLATE 1.

*Erica inordinata* H. A. Baker.

Photo: H. A. Baker.

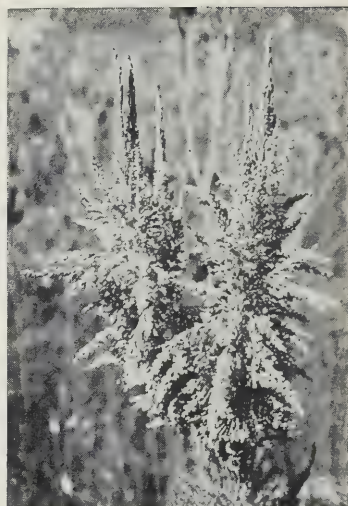


PLATE 2.

*Erica jacksoniana* H. A. Baker.

Photo: S. W. Chater.



PLATE 3.

*Erica parvulisepala* H. A. Baker. Showing the holotype on the left and the cream colour form on the right.

Photo: H. A. Baker.



mm long in a few specimens, glandular-viscid; bracts remote, 2—3 mm long, more or less ovate to obovate. *Sepals* variable in length from 3—6 mm, somewhat spreading, ovate, concave, the margins more or less inrolled and ciliate with viscid, sessile glands, glabrous, cartilagenous, 12-veined, coloured as corolla but after maturity becoming straw-coloured. The *corolla* varies much in shape and size with age, but apparently also for other unknown reasons. At first it is narrow-tubular with swellings round the anthers, white below and pink above but gradually becomes variously inflated below and much broader until, after the swellings round the anthers, the throat is very much narrowed, often asymmetrical, glabrous, extremely viscid and red or bright crimson, mostly

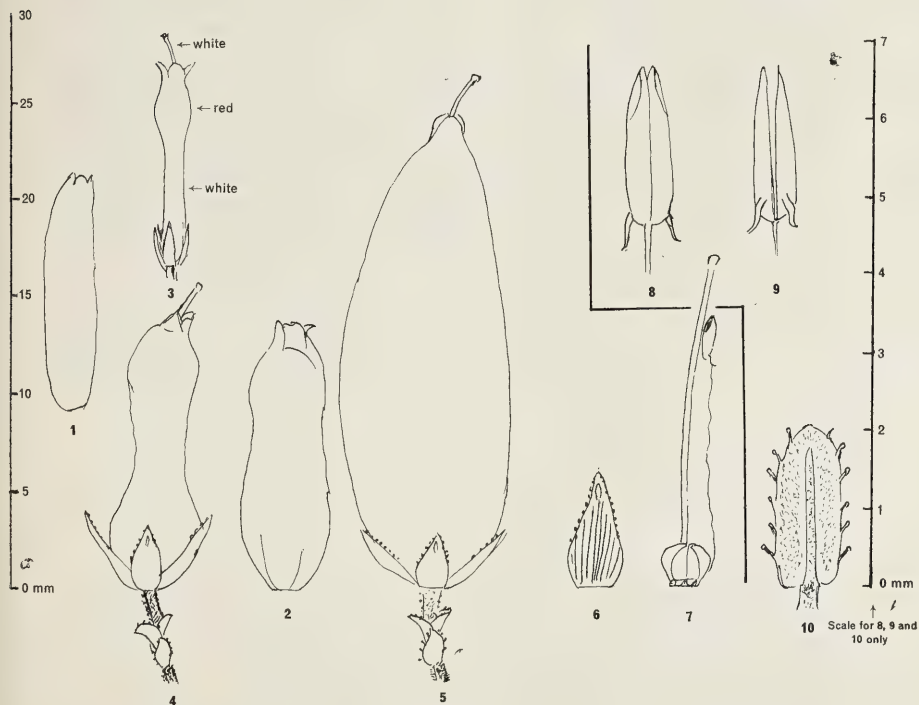


FIG. 1.

*Erica inordinata* H. A. Baker 1. and 2. Corollae; 3. very young and 4. very mature flowers; 5. exceptionally large flower from Hoopsberg; *Esterhuysen* collection 6529 in which the flowers are very variable 6. sepal; 7. gynoecium and stamen; 8. anther, front view; 9. anther, back view; 10. a leaf of average shape. All the above are from the holotype collection except No. 5.  
del. H. A. Baker.

about 15 mm long as in the type but up to 25 mm in some from Hoopsberg but only on a few flowers. Strangely, the sepals on these very long flowers are as short or even shorter than on the normal ones; lobes about 2 mm long on all the variants, slightly spreading at first, obtuse. *Filaments* slender to filiform; anthers included, 2 mm long, lateral, narrow-oblong, tightly pressed round the style by the narrow throat and tending to cohere, rough at the base, bipartite, awned; awns somewhat broad above, bent downwards and the points spreading, rough, pallid, about  $\frac{1}{3}$  the length of the cells; pore about  $\frac{1}{4}$  the length of the cells. *Ovary* broad-turbinate, glabrous; style exserted; stigma capitate.

*Erica inordinata* could be placed in *Evanthe* or *Pachysa* but, although it has the viscid and thick textured corolla of the *Pachysa* it has, especially when young, the tubular corolla and the solitary arrangement of flowers of some of the *Evanthe*. It does not have any marked affinity with any species in either section. Its chief interest botanically lies in the remarkable inconsistency in the shape and size of the flowers on various parts of the same plants. Some of this may be due to the swelling of the ovary with age but this by no means accounts for the other apparently haphazard, whimsical forms assumed by different flowers. The anthers also, though unremarkable in other respects, do appear to remain coherent in a tube round the style owing to their having no room to spread. This is a very unusual feature in the genus although in most species the anthers are pressed together in the immature state.

#### DISTRIBUTION

CAPE PROVINCE. Uniondale District, Mannetjiesberg, southern slopes to West of main peak c. 4500 ft, 18 Sept. 1967, *J. P. Rourke* 859 (NBG *holotype*; isotype BOL); *Ion Williams* 1075 l.c. (NBG); Kammanassieberg, Southern slopes 5000–6000 ft. 1 Feb. 1941 *Compton* 10559 (NBG); 3 Nov. 1941 *Esterhuysen* 6476 (BOL); Hoopsberg, Southern slopes 5000 ft., 6 Nov. 1941, *Esterhuysen* 6529 (BOL).

Rare and confined to the upper mountains in this locality. Flowers September to February.

***Erica jacksoniana*** H. A. Baker sp. nov. (Ericaceae- Ericoideae) Polycodon.

Frutex erectus, robustus ad 1.5 m altus. *Rami* pauci, fastigiati, ramulis numerosis, plus minusve fastigiatis, paniculatis, virgatis, 10 cm longis, floccosi pilis complexis. *Folia* 3-nata, 2.5–3.0 mm longa, aliquantum patentes, imbricata, liniaria, sulcata, glabra, ciliata pilis complexis et ad apices caespitosis, nudescens. *Flores* pro parte maxima 3-nata, in ramulis brevissimis terminales, subcorolini, numerosi; pedunculi 0.25 mm longi. glabri; bractae circa 1.25 mm longae, approximatae, adpressae, ovatae vel late ovatae, concavae, apicibus carinato-sulcatis, subscariosae, glabrae, similis foliis ciliatae sed pilis simplicibus,

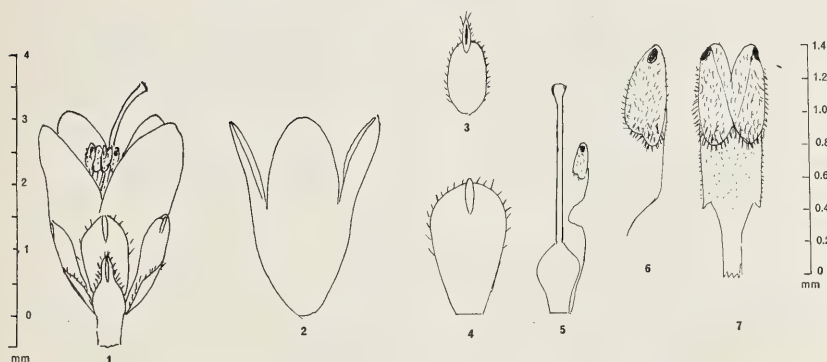


FIG. 2.

*Erica jacksoniana* H. A. Baker; 1. flower; 2. corolla; 3. bract; 4. sepal; 5. gynoecium and stamen; 6. anther, side view; 7. anther, front view.  
del. H. A. Baker.

albae. *Sepala* circa 1.75 mm longa, adpressa, obovata, apicibus carinatis, subscariosa, glabra, parce ciliata, alba. *Corolla* quasi 3 mm longa, obconica, sicca, glabra, rosea; lobi 1.6 mm longi, obtusi, ad maturitatem continui, tandem conniventes. *Filamenta* linearia, infra apices sigmoidentes, tum dilata, fuscata et rigidientia, leviter dentata et hispida; antherae inclusae sed manifestae, quasi 0.6 mm longae, dorsifixae, plus minusve oblongae, obtusae, bilobae, hispidae, muticae. *Ovarium* obovoideum, glabrum; stylo inclusio, tandem exserto, decurvo; stigmate capitato.

#### DESCRIPTION

Erect, robust shrub to 1.5 m or more. *Branches* few, fastigiate with numerous more or less fastigate, paniculate, virgate branchlets up to 10 cm long, floccose with compound hairs. *Leaves* 3-nate, 2.5–3.0 mm long, erect-spreading, imbricate, linear, sulcate, glabrous, the youngest ciliate with compound hairs and with a small apical tuft, becoming naked. *Flowers* mostly 3-nate, terminal on very short branchlets, subcorroline, very numerous; peduncles 0.25 mm long, glabrous; bracts approximate, closely adpressed, about 1.25 mm long, variable in shape, mostly ovate to broad-ovate, concave, keel-tipped, one often having a strong, more excurrent, green keel tip, subscariosus, thin, glabrous, ciliate like the leaves but with simple hairs, white. *Sepals* about 1.75 mm long, reaching to the base of the corolla-lobes or a little more, like the bracts but obovate, keel-tipped and only sparsely ciliate. *Corolla* a little over 3 mm long, obconic, dry, glabrous, pale below, rose above the sepals and soon turning brown; lobes continuous, obtuse, about as long as the tube, closing in after

maturity. *Filaments* broad, more or less, sometimes very sharply sigmoid near the apex, then dilated, rigid, dark-coloured and becoming as wide as the anther, slightly toothed at the base of the broader portion which is also shortly hispid; anthers included but manifest, 0.6 mm long, dorsifixed well above the base, more or less oblong, obtuse, bilobed, hispid, strongly so at the lower portions, mucous; pore minute. *Ovary* obovoid, glabrous; style at first included, then well exerted and becoming decurved; stigma capitate.

#### DISTRIBUTION

CAPE PROVINCE. Caledon District, Hottentots Holland Mountains, Eastern slopes of Moordenaarskop c. 3800 ft. 5 April 1967, *W. P. U. Jackson* s.n. (NBG, *holotype*; 5 April 1968 *Vogelpoel* s.n. (NBG); Landdrostskop, Eastern side July 1932, *Stokoe* 8883 (BOL); 17 March 1968 *Esterhuysen* 31948 (BOL); 18 May 1968 *H. A. Baker* 2911 (BOL); Somerset Sneeuwkop and environs April 1934 *Stokoe* 2838 (NBG, BOL). Flowers April to July and probably longer.

#### ACKNOWLEDGMENTS

The author is grateful to Mr Ion Williams for collecting these specimens for him and to Mr. John Rourke who collected the ones chosen as the type at the same place and date.

*Erica jacksoniana* appears to be confined to Eastern slopes of the Hottentots Holland Mts. in the general area from Landdrostskop to Moordenaarskop. It is frequent in marshes and on wet mountain slopes between 3,000 and 4,000 ft, more or less and has been found by the author growing to 5 ft and apparently still growing strongly. It has been placed in section 37 Polycodon owing to its resemblance in general aspect to *E. floribunda* Lodd. but it is, in other respects, a very distinct species and might equally well have been placed in section 38. The anthers are particularly interesting. As depicted in Fig. 1 the enlarged and thickened portion of the filaments below the cells, which is hispid and coloured like them, might be considered an extension of the anther with appendages fused to it and with very small free points. In some collections from Landdrostskop the sigmoid kink in the filaments is not very marked whereas in those from the type locality it is extremely so. Also those from the former locality have the delicate flowering branchlets spreading in a panicle which shimmers in the wind, a very attractive feature, whereas those from the type locality were consistently fastigate. It would appear that these branchlets become fastigate again after flowering and become naked and dead as the stems lengthen.

*E. jacksoniana* is named in honour of Professor W. P. U. Jackson who



collected it in 1967 and brought it to the notice of the author. He is a very enthusiastic mountaineer and collector of rare and interesting species. He, with the author and two other enthusiasts, Dr. J. Macgregor and Dr. L. Vogel-poel revisited the site in 1968 to confirm details.

***Erica parvulisepala*** H. A. Baker sp. nov. (Ericaceae-Ericoideae) Evanthe.

Frutex erectus, robustus, fere 60 cm altus. *Rami* tomentosi, ramulis numerosis, brevibus, approximatis. *Folia* 4-nata, 5—7 mm longa, erecto-effusa, incurva,

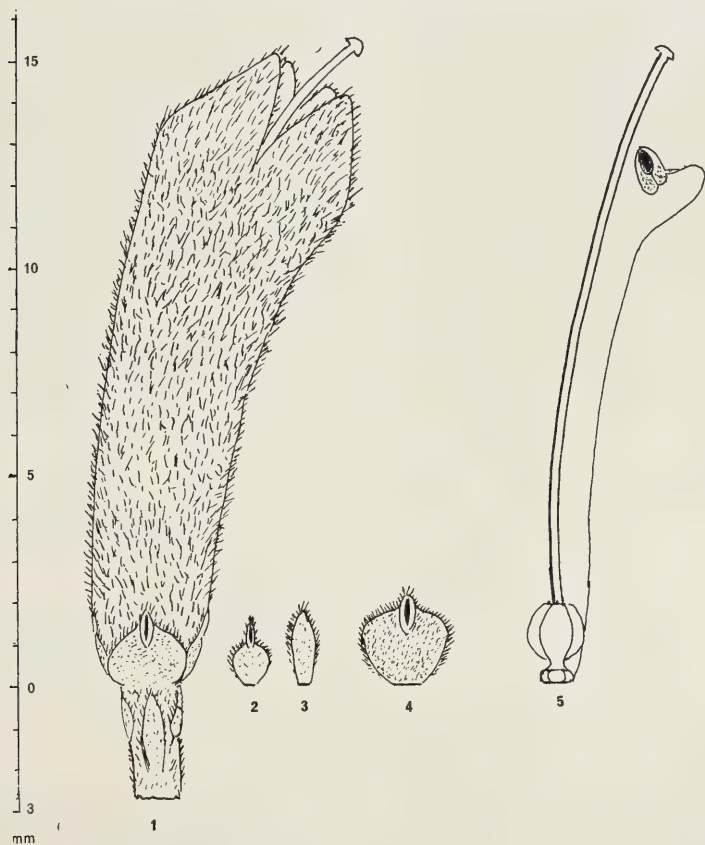


FIG. 3.

*Erica parvulisepala* H. A. Baker. 1. flower; 2. and 3. bracts; 4. sepal; 5. gynoecium and stamen.  
del. H. A. Baker.

arte imbricata, lineari-subulata, subtrigona, carinata, hirsuta pilis ad bases tubercularibus, glabrescens. *Inflorescentia* pseudoracemosa; flores terminales, pro parte maxima solitarii; pedunculi 1.5—3.0 mm longi, pubescentes; bracteae remotae, parvulae, variabiles. *Sepala* 1.5—2.0 mm longa, late obovata vel orbicularia, imbricata, apicibus carinatis, mollia, velutina, dense ciliata pilis longis, mollibus, albis; apices sulcati, partim excurrentes, virides. *Corolla* 1.3—1.5 cm longa, aliquot variabilis, tubularis, sursum dilatata, plus minusve curva, circum antheras tumida, gracilis, nervata, sicca, hirsuta, rosea, vel interdum crenea. *Filamenta* linearia, gracilia, rosea, infra antheras cinea tum dilata, brunnea, ad antheras affixa ad angulum fere 90°, antherae inclusae, 1.2 mm longae, laterales, oblongae, cuneatae, bipartae, muticae, scaberulae; poro fere dimidio pars lobi. *Ovarium* turbinatum, glabrum, roseum, 4-cellu, laris, 4-lobis, breviter stipitatum, disco nigro superpositum; stylo exserto, stigmatе capitato.

Erect, robust shrub of marshy places to 60 cm or more. *Branches* tomentose. *Leaves* 4-nate, 5—7 mm long, erect-spreading and incurved, closely imbricate, linear-subulate, subtrigonal, keeled, hirsute with tubercular-based hairs, glabrescent, the tubercles persistent. *Flowers* 1—3-nate mostly solitary, terminal on short, leafy branchlets forming a pseudoraceme below the ends of the branches; peduncles 1.5—3.0 mm long, pubescent; bracts remote, small and narrow. *Sepals* 1.5—2.0 mm long, mostly concealed by the leaves, broad obovate to orbicular, imbricate, keel-tipped, soft in texture, velutinous and densely ciliate with long, soft hairs, white, the green keel-tip sulcate, partly excurrent and hairy. *Corolla* 1.3—1.8 cm long, somewhat variable in shape owing to crowding and development, tubular to clavate-tubular, more or less curved, somewhat dilated round the anthers, thin in texture and veined, dry, hirsute, flamingo-pink or cream, the latter rather shorter. *Filaments* linear, slender, rose-coloured, sharply curved below the anthers and thence dark-coloured, dilated and attached to the cells nearly at a right angle; this portion of the filament might be considered to be a produced part of the connective with appendages fused to it but there are no free points; anthers included, 1.2 mm long, lateral, oblong-cuneate, bipartite, scabridulous, dark brown; pore about half the cell. *Ovary* turbinate, rose-coloured, 4-celled, 4-lobed, shortly stipitate and seated on a dark disc; style exserted, stigma capitate.

#### DISTRIBUTION

CAPE PROVINCE: Caledon and Robertson Districts. Riviersondereinde Mts. above Greyton between Kanonberg and Galgeberg marshy places at 4,000 ft and above, *Baker* 2801 (NBG holotype; BOL), cream form *Baker* 2802 (NBG; BOL). Flowers in spring.

This very beautiful species was first brought to the notice of science at a wedding reception where flowers from Mr. Wessels' farm near Greyton were amongst the decorations. The author was introduced to it by Mr. J. Rourke of the National Botanical Gardens Herbarium at Kirstenbosch. A special trip was arranged by the author and Dr. L. Vogelpoel to this farm but the whole area was burnt the day before. Mr. Wessels kindly gave us the contents of the vases at his home which included specimens of the cream one. Later, on a trip to Galgeberg, Dr. Vogelpoel and Mr. J. Marais collected more specimens from another marsh in the same general environment.

It appears to be confined to marshes at 4,000 ft and above in the Rivier-sondereinde Mts. above Greyton between Kanonberg and Galgeberg. *Erica parvulisejala* is closely allied to *E. colorans* Andr. and only after critical comparison has the author decided to give it specific rank. It differs chiefly in having tubercle-based, hairy leaves, pubescent peduncles, very insignificant bracts and extremely small, entirely different-textured and hairy sepals; different-shaped, longer, hirsute, coloured corolla of a much thinner texture. The structure of the anthers is very similar but the shape of the ovary is different. *E. colorans* was not found in the vicinity, and has not been recorded North of Latitude 34° 20'.

***Erica colorans* Andr. var. *hispidula* H. A. Baker var. nov.**

A forma typica ita differt; *corollae* dense hispidulae, albae. *Sepala* grosse setosi-ciliata, aliquot seteris ramificans.

#### DISTRIBUTION

CAPE PROVINCE. Caledon/Bredasdorp Districts on the feature Paardeberg above Sandie's glen on the farm Fairfield, 27/10/1961 *H. A. Baker* 1864 (NBG holotype); 17/9/1967 s.l. *H. A. Baker* 2800 (NBG, BOL).

#### DESCRIPTION

*Corollas* densely hispidulous, white. *Sepals* coarsely setose-ciliate with some of the setas branched.

#### NOTE ON *E. COLORANS* ANDR. VAR. *BREVIFLORA* AND *E. PAUCIOVULATA*

Both the above, described by the author, (J. S. Afr. Bot. 31: 160-161; 28: 200-223) have been found, on closer investigation, to be frequent on the Paardeberg feature often growing in association. The former, however, is always in boggy ground, the latter in bog, seepage or marsh and often of sturdier form than the type, where not recently burned.





**CYRTANTHUS BREVIFLORUS AND CYRTANTHUS LUTEUS  
(AMARYLLIDACEAE): OBSERVATIONS WITH PARTICULAR  
REFERENCE TO NATAL POPULATIONS†**

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ABSTRACT

The history of *Cyrtanthus breviflorus* Harvey = [*Anoiganthus breviflorus* (Harvey) Baker] and *Cyrtanthus luteus* Baker = [*Anoiganthus luteus* Baker] is briefly outlined.

During the years 1960–67, field populations in Natal, and plants from these populations under cultivation, were studied: habitat features and some morphological parameters are given. Leaf anatomy, chromosome numbers and distribution in South Africa are dealt with. The proposal is made that *C. luteus* should be reduced to synonymy.

Harvey (1859) based *Cyrtanthus breviflorus* on three specimens from the eastern Cape (Krauss 255, summit of the Kaga Berg; H. Hutton, about the sources of the Kat River, 6,000 ft; T. Cooper 255, Umgauka Kop, in marshy ground), all of which were stated to "... precisely agree". The description mentions, "leaves flat, strap-shaped, 12–15 inches long,  $\frac{1}{2}$ – $\frac{3}{4}$  inches wide, tapering to a bluntish point", and "umbrella 6–9 flora". Harvey likened *C. breviflorus* to [*C. lutescens*, Herb.] = *C. ochroleucus* (Herb.) Burch., but distinguished his species by its "short flowers and much broader flat leaves".

Baker (1876) described *C. luteus* as an interesting novelty enclosed in a packet of monocotyledons received from Rev. J. Buchanan of Durban. The leaves were stated to be 2–3, very narrow, linear, glabrous and longer than the solitary flowered scape. No affinities were mentioned.

Two years later Baker (1878) erected the genus *Anoiganthus*, separating this from *Cyrtanthus* on the more widely spreading, shorter perianth. To *Anoiganthus* he referred both Harvey's *Cyrtanthus breviflorus* and his own *C. luteus*, distinguishing one from the other on leaf and umbel characters.

Killick (1960) drew attention to the generic differences between *Cyrtanthus* and *Anoiganthus* as interpreted and applied by various authors, and pointed out the rather surprising use in this connection of anther attachment by Baker

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† Accepted for publication 11th April, 1968.



FIG. 1. Anthers of *Cyrtanthus breviflorus*.  
 A—before dehiscence showing dorsifixed attachment; B—after dehiscence; C—anthers versatile on aging.

(1888; 1896) (versatile in *Cyrtanthus*; basifixed in *Anoiganthus*), and also by subsequent authors. As Killick has stated, there is no doubt that the anthers in *Anoiganthus* are versatile (see Fig. 1). Wilsenach (1963) also drew attention to the dorsifixed and versatile anthers of *Anoiganthus*. Both authors referred to perianth form, the only other criterion that has been used to separate the genera, and emphasized that neither the more widely spreading tube, nor its shorter length in relation to segment length, were valid in differentiating these genera. Despite supporting evidence from chromosome studies, Killick suggested the matter should await the considered opinion of some future monographer of *Cyrtanthus*. But Wilsenach concluded that from morphological, cytological and genetical data, segregation of the species into two genera was artificial. He provided a modified concept of *Cyrtanthus* to incorporate *Anoiganthus*, which to date, however, does not always seem to have been applied.

Following this conclusion, the species under consideration here should be known by their earliest names, *Cyrtanthus breviflorus* Harvey and *C. luteus* Baker.

A problem now requiring clarification is the taxonomic relationship of the plants referred to these species. Not all authorities agree that two species are represented, nor is there always uniformity in application of the specific names. If Baker's original description is strictly adhered to, the name "luteus" should be applied only to plants bearing single-flowered scapes. Baker (1888) himself referred *A. luteus* to *A. breviflorus* as *var. minor*, delimiting it as, "dwarf, 1—2 flowered, with short pedicels and narrow perianth segments". In *Flowering Plants of South Africa*, letterpress accompanying Plates 144 and 539 (1924 and 1934 respectively), it is suggested that the viewpoint of Medley Wood, Hutchinson and others that two distinct species are represented, may well be correct. Medley Wood is stated to have found that "*A. breviflorus* grows in swampy ground, commencing at about 1,500 ft (457 m) above sea level and is found upwards to 4,000 ft (1,219 m)", while "... *A. luteus* appears on grassy hills and plains from just above sea level to 2,000 ft (610 m), but never in swamps." Hutchinson pointed out that critical consideration of specimens at Kew confirmed these observations, and then continued, "The flowers and leaves appear to be always contemporaneous in *A. breviflorus*, but in *A. luteus* the flowers appear first and the leaves are very small". The plate (No. 144) accompanying Hutchinson's statement and showing *A. breviflorus* with wide leaves (7—14 mm broad according to description) and an umbel of nine flowers, "was prepared from plants collected near Springfield (Durban), Natal". The last statement, if entirely accurate, is not in agreement with Medley Wood's findings, for Springfield, at most, does not exceed 500 ft (152 m) in altitude.

Later observers (F.P.S.A. plate 539, 1934) referred plants with 1, 2 or 3-flowered inflorescences to *A. luteus* and commented, "Specimens... from

Johannesburg and Barberton have leaves which are broader than the coastal specimens and are also contemporary with the flowers, but we do not think that this is sufficient to keep them separate from *A. luteus*".

Interest in morphological variability within and among populations of these two "species" and the distribution of these populations in relation to habitat and altitude, led to study of plants in the field, under cultivation, and in South African herbaria. It is hoped the data that follow may partially satisfy the request by Hutchinson (1924) for further notes by Natal botanists and may stimulate other workers to further field investigation of *Cyrtanthus* and its allied genera, some of which exhibit comparable problems of variability and close specific relationship (*Haemanthus*, *Brunsvigia*). It is also hoped the data may prove of some interest in connection with cytogenetic and genetic studies at present being undertaken within *Cyrtanthus* (Ising, 1962, 1966).

#### MATERIALS AND METHODS

Populations of plants of *C. breviflorus* and *C. luteus*<sup>1</sup> are generally fairly clearly demarcated when flowering, because of the somewhat specialized, and therefore localized habitat conditions favoured. Fire is important, for burning removes the previous year's grass cover, resulting in increased insolation and higher soil temperatures, so that extensive flowering of a population often takes place as little as a week after firing. Against the almost bare soil, plants are readily detected and studied. Between the years 1960-67, populations in Natal were located, studied and sampled.

Across each population an arbitrary line transect was selected in order best to traverse the habitat conditions under which plants were growing. Data were recorded from plants at stipulated pace intervals across the transect, the length of these intervals depending upon the area occupied by the population. Attempts were made to obtain parameters from not less than twenty plants in each population, but population extent did not always permit of this.

Populations were re-visited at intervals over the seven years of the study. After flowering, when the grass cover became thick and matted, plants proved difficult, or impossible, to detect, due probably to the early dying-off of leaves, at least in some cases.

In order to obtain information from populations over as wide a range of locality and habitat as possible, further populations found by observers other than the authors, were studied by means of representative plants brought to the laboratory. From every population studied, usually not less than ten

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<sup>1</sup> For purposes of this study all populations falling within the limits of *C. breviflorus* and *C. luteus* were considered. No attempt was made during the course of the work to relate any population to either species.



plants regarded as representative of the community as a whole, were removed and planted in pots in reasonably uniform loam soil. Pots were kept indoors as near as possible to large windows with south east facing aspect, and watered regularly. No attempt was made to record amounts of water supplied. On a few occasions some degree of drying occurred, but this was insufficient to cause death of existing leaves. In 1965, a sunny greenhouse became available and pots were transferred to this, being placed in trays in which standing water was usually present. Observations of these plants were made at intervals.

To make the study more complete, herbarium material was also considered and a survey of specimens deposited in the under-named herbaria undertaken to obtain further information that might relate morphological features, habitat conditions and distribution. The morphological features considered in particular, were:

- presence or absence of leaves at time of flowering
- width of mature leaves at flowering (when present)
- number of flowers to inflorescence
- bract coloration
- perianth length

The herbaria were:

- National Herbarium, Pretoria
- Natal Herbarium, Durban
- Albany Museum, Grahamstown
- Bolus Herbarium, University of Capetown, Rondebosch
- Government Herbarium, Salisbury, Rhodesia
- University of Natal Herbarium, Pietermaritzburg

## RESULTS

The main populations studied in the field, with brief description of respective habitat conditions, are listed in Table 1. Leaf and inflorescence parameters obtained at initial and, in some cases, at subsequent sampling are given in Table 2. Parameters obtained from periodic measurement of plants under cultivation are given in Table 3. In general, two sets of measurements only have been included, the first of 11.8.62, representing two years under cultivation indoors; the second of 11.4.67 representing a further four years and some months under cultivation, the last two years under conditions of plentiful water in a sunny, fan-cooled greenhouse.

## CONCLUSIONS

### (a) *From study of field populations*

Flowering takes place generally in spring. Records covering June to February inclusive, exist, but the main flowering period is July to October, the precise

TABLE 1—Representative field populations of *Cyranthus breviflorus* studied in Natal during the years 1960–67 (other populations from the same general localities listed were studied, but were too numerous to indicate here).

District	Locality	Population Symbol	Habitat
Pietermaritzburg	Scottsville, Dulwich Road	DR	recently burnt grassland: plants in local depression: alt. 671 m
	Scottsville, Oribi Camp	OC	recently burnt grassland: slight e.-facing slope: alt. 671 m
	Scottsville, Cleland	CL	recently burnt grassland: plants in shallow, moist dep. alt. 671 m
Lions River	Town Hill, Queen Elizabeth Park	QP	localized low-lying vlei into which water drained: alt. 823 m
	Karkloof, road from farm "Tetworth" to Curries Post:	KR	streambank: plants 1–2 m from water: soil dark: alt. 1280 m
	farm "Owhilln", portion of Tetworth	KD	opposite bank of same stream: rocky, grass-covered knoll, among rocks in grassveld on steeply-sloping, e.-facing hillside: alt. 1371 m
		KO	
Estcourt	Kamberg Nature Reserve sites A–F respectively	EA	grassveld on slope with n.-facing aspect: alt. 1646 m
		EB	grassveld on slope with n.-facing aspect: alt. 1646 m
		EC	stream: plants on banks, in water or in marshy soil: 1631 m
		ED	vlei area: no standing water: alt. 1829 m
		EF	grassveld of steep n.e.-facing slope: alt. $\pm 1650$ m
	Tabamhlope mountain farm "Broadmoor", approx 14 m from Mooi River towards Drakensberg	TS	semi-vlei to drier grassveld: plants in peaty soil: alt. 1676 m
		M	vlei: plants in standing water or in wet vlei soil: alt. 1585 m
		B	banks of Bushman's River at site of dam: plants in massive clumps pendulous over water: alt. 1219 m
	Giant's Castle Game Reserve	D	plants on islets of land in standing water of vlei: alt. $\pm 2300$ m
	Giant's Castle Game Reserve	BP	streambanks of small streamlets, e.-slopes of Drakensberg: peaty soil: rainfall approx. 1500 mm per annum: alt. 2317–2743 m
Mpendhle	Giant's Castle Game Reserve farm "Whiterocks", top of little Drakensberg	BPS	Bushman's River Pass: vlei with some standing water: alt. 3048 m
		W	moist vlei, lacking standing water at time of collection of plants: alt. 2134 m
Pinetown	Gillits, Everton	G	grassveld of steep, rocky hillside: alt. 610 m
Port Shepstone	Umtentweni—St. Faith's Road	PS	recently burnt grassveld near forest margin: alt. 457 m
Durban	Bluff, Treasure Beach	TB	recently burnt, rather sparse grassveld: soil sandy: alt. $\pm 15$ m
Durban—Umlazi boundary	Umgababa—Umbumbulu Road, near Illovo River	U	recently burnt grassveld of streambank: alt. $\pm 122$ m (grass black at time of collection of plants).

TABLE 2—Parameters of leaf and inflorescence characters of some field populations studied in Natal (original and, in some cases, subsequent examination)

Population Symbol	Date of examination	No. of plants examined	No. of plants with no. of leaves developed						Leaf width in mm		No. of flowers to inflorescence			Colour of bracts, peduncle leaf bases
			0	1	2	3	4	5+	min.	max.	min.	max.	mode	
DR	11.8.60	33	25	5	1	2	0	0	1.9	2.2	2	8	5	purple
OC	24.8.60	24	24	0	0	0	0	0			2	7	3	purple
QP	21.8.67	22	5	8	2	5	2	0	14.0	19.0	4	17	10	purple
KR	20.8.60	4	0	0	0	3	1	0	9.0	11.0	5	5	5	green
KD	20.8.60	20	17	3	0	0	0	0	0.6	1.0	1	2	1	purple
KO	20.8.60	20	15	3	2	0	0	0	0.7	1.2	1	1	1	purple
EA	15.9.65	30	24	5	1	0	0	0	$\pm 4.0$	$\pm 8.0$	1	5	3	green-purple
	19.9.66	30	26	4	0	0	0	0	$\pm 4.0$	$\pm 8.0$	1	4	2	green-purple
EB	17.9.65	70	57	11	2	0	0	0	$\pm 3.0$	$\pm 8.0$	1	6	2	green-purple
	19.6.66	no flowering plants represented: site burned 5.9.66: 6 flowering plants noted $\pm$ week after burning, died off by 19.9.66.												
EC	19/20.9.65	48	0	4	20	16	5	3	$\pm 3.0$	$\pm 11.0$	2	5	2	green
	24.9.66	50	0	7	26	16	1	0	$\pm 3.0$	$\pm 11.0$	2	5	2	green
ED	21/22.9.65	50	0	0	9	33	8	0	$\pm 3.0$	$\pm 11.0$	1	5	2	green
	20.9.66	50	0	4	24	16	6	0	$\pm 3.0$	$\pm 8.0$	1	5	2	green
EF	9.65	no plants visible: site unburned 1965: burned 15.9.66												
D	27.9.66	50	50	0	0	0	0	0			1	5	2	green-purple
BP	27.9.60	3	0	0	0	3	0	0	13.0	19.0	5	12		green
BPS	4/5.11.67	2	0	0	0	2	0	0	33.7	38.0		6		green
W	4/5.11.67	5	0	0	0	3	2	0	5.9	7.4	3	5	5	green
G	7.9.66	10	8	2	0	0	0	0	3.0	4.0	2	2	2	purple
PS	18.8.63	20	16	4	0	0	0	0		$\pm 1.5$	1	3	1	purple
TB	3.8.63	15	15	0	0	0	0	0			1	1	1	purple
U	27.8.67	25	4	17	4	0	0	0	1.5	4.3	1	5	2	purple
	27.8.67	22	22	0	0	0	0	0			1	5	3	purple

TABLE 3—Parameters of plants under cultivation, originally from field populations studied

Population Symbol	Date of Examination	Period Under Cultivation	No. Plants Examined	No. Leaves Measured	Leaf Width			Features of Interest
					Min.	Max.	Mode	
DR	11.8.62	2 years	3	41	1.3	4.7	3.3	plants permanently leafy plants permanently leafy no. flowers per peduncle 3—5 several modes for leaf width
	11.4.67	6 years 8 mths.	3 + asexual progeny	20	2.0	3.1	3.0	
OC	11.8.62	2 years	4	23	1.2	4.9		no inflorescences produced young vegetatively propagated bulb with leaves 2.0 mm wide plants permanently leafy; other plants died: no inflorescences several modes for leaf width old plants with wider leaves (3.5— 4.0 mm developed centrally among narrower ones: no inflorescences sporadic flowering several modes for leaf width several modes for leaf width
	11.4.67	6 years 8 mths.	4 + asexual progeny	20	2.2	4.1	3.0	
KR	11.8.62	2 years	2	2	9.8	10.2		plants permanently leafy; other plants died: no inflorescences several modes for leaf width old plants with wider leaves (3.5— 4.0 mm developed centrally among narrower ones: no inflorescences sporadic flowering several modes for leaf width several modes for leaf width
	11.4.67	6 years 8 mths.	2 + asexual progeny	6	7.8	15.3		
KD	11.8.62	2 years	3	4	1.3	1.5	1.3	inflorescence with 3-flowers inflorescence with 4-flowers
	11.4.67	6 years 8 mths.	1	1	1.2			
KO	11.8.62	2 years	5	12	1.0	2.0		inflorescence with 3-flowers inflorescence with 4-flowers
	11.4.67	6 years 8 mths.	3 + asexual progeny	10	1.0	4.2	1.7	
TS	11.8.62	2 years	2	6	3.9	6.9		inflorescence with 3-flowers inflorescence with 4-flowers
	11.4.67	6 years 8 mths.	2	14	4.3	7.5	5.0	
M	11.8.62	2 years	4	9	4.1	8.3		inflorescence with 3-flowers inflorescence with 4-flowers
	11.4.67	6 years 8 mths.	4 + asexual progeny	12	2.5	6.1		
D	11.8.62	2 years	1	1	9.0			inflorescence with 3-flowers inflorescence with 4-flowers
	10.9.66	6 years 1 mth.	1	3	5.9	6.9		
W	11.4.67	6 years 8 mths.	1 + asexual progeny	7	3.9	9.4		inflorescence with 3-flowers inflorescence with 4-flowers
	11.4.67	7 months	6	18	2.0	3.8	2.8; 3.0	

dates depending upon local conditions and the time of firing of the grass cover.

Populations mostly occur in two main types of habitat, which, at their extremes, are very different, namely, vle/streambank/stream and grassveld. Plants occupying vle/streambank/stream habitats may be characterized as follows:

Bulbs often narrow, in many cases not exceeding width of base of aerial shoot. Leaves mostly present at flowering, generally 3—6 per plant, 10—38 mm wide. Inflorescences often solitary per plant, sometimes 2—3, peduncles more or less equalling leaf length at time of flower opening, green. Flowers 6—17 per peduncle, bracts after opening, up to 6 cm long, 7—10 mm wide basally, green. Capsules oblong to elliptic before dehiscence.

Grassland plants may be characterized by:

Bulbs generally elliptic to spherical, usually clearly exceeding width of base of aerial shoot. Leaves mostly undeveloped at flowering, eventually 1—4 per plant, 1—3 mm wide. Inflorescences often 2—3, sometimes solitary per plant, peduncles often developed only to ground level at time of flower opening, later elongating and becoming purple, especially basally. Flowers 1, occasionally 2 per peduncle, bracts after opening, 20—25 mm in length, 1—3 mm wide basally, purple. Capsules oblong to oblanceolate before dehiscence.

There is a robustness about vle/streambank/stream plants that contrasts markedly with the more delicate, slender, usually shorter plants of grassland situations.



FIG. 2. Range of flowering plants from localities in Natal.  
a—Durban, Bluff, Treasure Beach (TB); b, c, e—Umgababa—Umbumbulu Road (U); d—Cieland, near Pietermaritzburg (CL); f—Town Hill, near Pietermaritzburg (QP); g—Giant's Castle Game Reserve, e, slopes of Drakensberg (BP); h—capsules from population (BP).



Between these extremes, a range of populations occupying what appear to be intermediate habitats, and composed of plants intermediate in morphological form, exist. Despite their intermediate nature, many of these populations can still be related either to the vlei/streambank/stream, or to the grassland type, depending, it would seem, on whether precise habitat conditions approach more closely to an hygrophilous, or to a drier grassland environment. It should be pointed out that populations are not to be found throughout all grassland areas. Although no quantitative data are available in support, since it proved impossible to undertake measurement of habitat conditions in this preliminary study, it seems from observation of field conditions, that a certain minimum water availability is required before populations are able to endure. Thus it is that plants are usually located in more or less depressed areas in grassland where water might collect, or on rocky slopes where earth pockets may remain moist, despite fairly rapid run-off from the whole area.

Where annual rainfall is high (about 1,500 mm), populations do not seem so restricted to the abovenamed local situations in grassveld, since, no doubt, the high rainfall maintains at least minimal moisture requirements over the whole grassland area.

Above 2,134 m (7,000 ft) on the Drakensberg, the steep grassy slopes (where plants sometimes occur), must be considered the equivalent of vlei, rather than of grassland situations at lower altitudes, for the high rainfall makes conditions mostly very moist. Fig. 2 shows a range of plants collected from localities in Natal (see legend to figure for details).

Vlei/streambank/stream and grassland populations may occur in close proximity to one another. Striking in this regard were populations KR and KD (Table 1) where not more than 8 m separated robust, leaf-bearing, streambank plants with peduncles carrying about five flowers (morphological form approximately represented by stoutest specimen Fig. 3A), from delicate leafless, grassveld plants bearing single flowered peduncles (morphological form approximately represented by smallest plants Fig. 3B). Also worthy of mention are populations at Giant's Castle Game Reserve, Estcourt district, Natal, represented by dried specimens, namely Skead 199 NU, collected 26.9.61, at 1,859 m from "moist soil, open grassland" and Skead 204 NU collected 1.10.61, at 1,737 m altitude, "from steep west-facing slope in open grassland". The former is robust and leaf-bearing (compares well with Fig. 2F), the latter slender and leafless with a wide bulb and delicate peduncle carrying two flowers (fair comparison with Fig. 2e, but bulb here much smaller and peduncles two, each solitary flowered).

Usually plants constituting a population are reasonably uniform in robustness, in extent of leaf development and leaf width, in time of flowering and flower number per peduncle. Particularly is this so of populations where the





FIG. 3. Plants taken at random from natural populations, showing intra-population uniformity of morphological form.  
 A—Estcourt distr., : Highmoor Forest Reserve, vlei: alt. 2105 m : 10.9.67. B—Estcourt distr., Gladstone's Nose, grassveld, firebreak burnt every second year (not burnt 1966): 11.9.67.

previous year's grass cover was fired (vlei/stream/streambank populations generally have a slightly longer flowering period, not all plants commencing flowering at once). Fig. 3 shows some of the plants sampled from two populations indicating this general uniformity (see also legend).

Despite the general intra-population uniformity, it is usual, in most populations, to find a few plants more or less robust than the majority. These differences appear correlated with differences in the microhabitat. Fig. 4 shows examples of intra-population variation from two coast populations. Drakensberg plants have afforded yet more striking evidence in support of the apparent relationship between morphological form and conditions of the microhabitat. For example, Fig. 2g (leaves 36—38 mm wide) was from a streambank population growing in soft, loose soil with a good deal of organic matter present (average rainfall approximately 1,500 mm per year: verbal communication by Warden, Giant's Castle Reserve to F. B. Wright). Other plants from the same population growing under what seemed, on visual estimation (which, it must not be forgotten, can sometimes be mis-leading) to be poorer conditions, were less robust (leaves 12—14 mm wide).

Thus it must be suggested from field observation that habitat conditions play some part in determining general morphological form of plants constituting populations, and that within populations, localized microhabitat differences may also exert an influence on groups of plants, or on individuals. Factors that seem particularly significant are amounts of available water throughout the year and of organic matter within the soil, but quantitative experimentation is needed to support these ideas.

Field observation has repeatedly provided evidence that robustness of morphological form is not directly correlated with altitude (see Table 1).

Bulb size varies greatly among plants having reached flowering age (Fig. 2) and is certainly correlated with overall plant size. There is also a general tendency for grassland plants to develop bulbs wider relative to width of leaf bases at ground level, than is the case with plants of vlei/streambank/stream environments. This is surely the outcome of drier habitat conditions. Bulbs are frequently linked underground by fleshy rhizomes usually broken at time of removal from the soil (Fig. 5A).

Perianth form is variable. Some differences in overall perianth length, perianth lobe width and degree of opening of lobes are shown in Fig. 6. It is not surprising that perianth length shows some variation when plants as different as those of Fig. 2a and h are compared, but the variations are not limited to such extremes. Fig. 6c—f are from the same population and show variation in overall perianth length and in spread of lobes in flowers of approximately the same age, developed on different plants. Spreading of lobes is usual in response to strong light, but even under uniform illumination some perianths

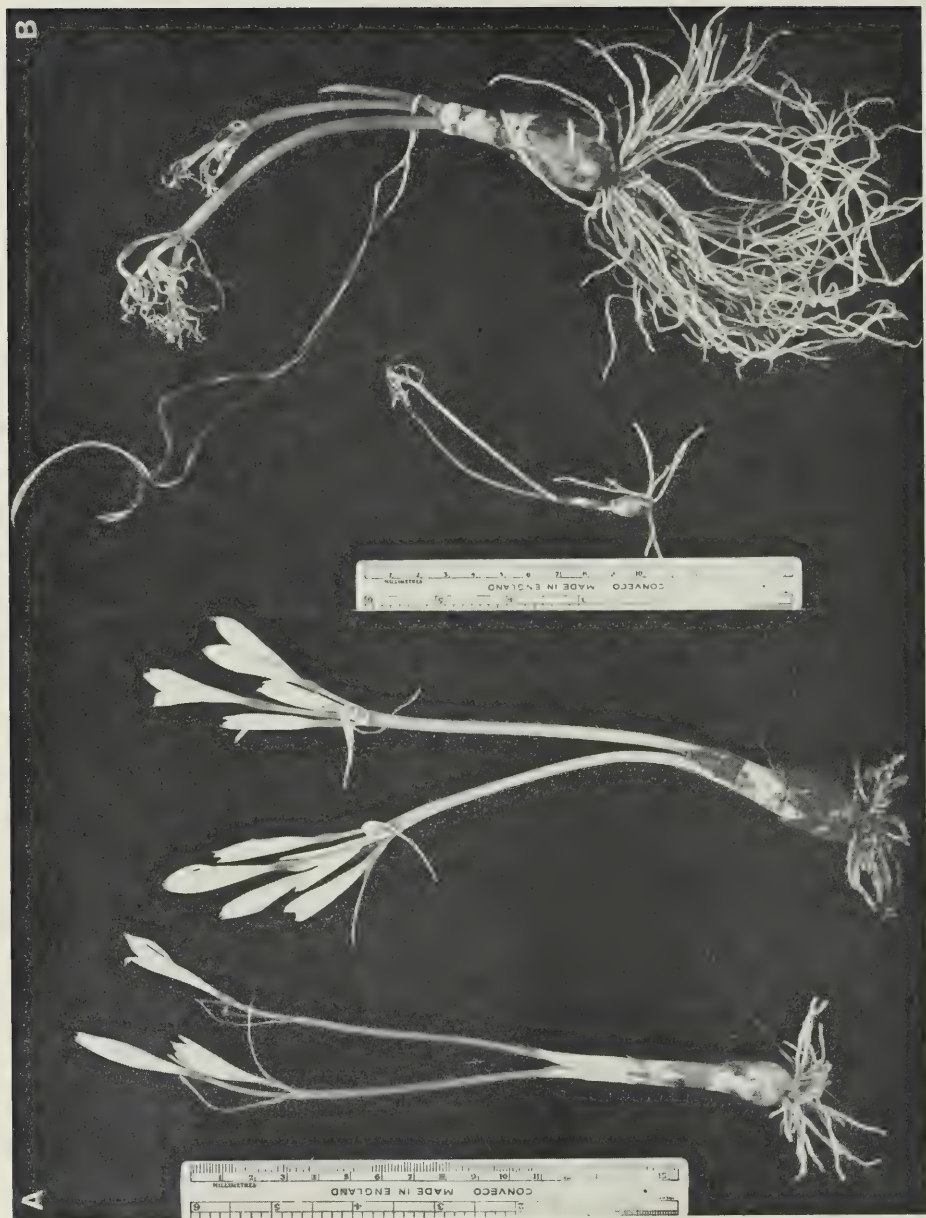


FIG. 4. Plants from natural populations, showing evidence of intra-population variability. A—Population U, Umgababa—Umbumbulu Road. B—Population TB, Durban Bluff: note old leaves persisting and root development in sand (right).



do not open as widely as others. Differences in flower form such as are shown in Fig. 6a, b, have been observed in the field (Cato Ridge, Gordon-Gray: plants in deep shade of shrub with flowers as a; majority of population in sunlight with flowers as b).

The number of capsules maturing seed within a population during a season is usually markedly less than the number of flowers produced. After fertilization, peduncles elongate rapidly and become stouter so that seed is shed above the level of the surrounding vegetation. Variation in capsule form exists (Fig. 5B): the longer more slender capsules (Fig. 5B, a, b, c) generally, but not always (Fig. 5B, e), being developed by plants from grassland situations. Such elongated form may be the outcome of the rapid growth and maturation of flowering organs that is especially noticeable in populations occupying what appear to be drier microhabitats.

Populations do not necessarily flower and thus become evident each year, nor, when flowering does take place, are comparable numbers of plants visible in different years (especially is this so with plants growing in grassveld). Bulbs appear able to remain dormant for up to three years before again producing leaves and flowers. Sampling of the same population over more than one year suggests leaf number per plant, leaf width, and flower number per peduncle, may differ slightly from year to year. The range of variation in no way covers the intra-population range, however.

Aerial portions of the plant are susceptible to frost, peduncles, flowers and leaves being destroyed by one exposure. Observation shows, however, that in the same approximate locality, frost damage is not always uniform, depending, it would seem, upon situation and conditions of the microhabitat. Populations EA and EC, on the night of 25.9.65 were subjected to unseasonal, severe frost. All aerial parts of grassveld plants (EA) were destroyed, only stakes used as markers allowing their subsequent location. Among streambank plants (EC), however, peduncles and developing capsules were killed, but little, if any, leaf damage occurred.

Among grassland plants, in particular, but also applying in vlei/streambank/stream situations, the aerial parts are not of long duration. Seventeen plants within a grassveld population in the Kamberg Nature Reserve, Estcourt district, were marked by stakes on 27.9.66 when open flowers, but no leaves, indicated their presence. By 11.12.66, one peduncle withering from the top, was the only remaining trace of all seventeen plants. During the intervening period, leaves had developed and withered, capsules had matured and shed seed. Fig. 4B (right) shows evidence of old leaves still persisting at next season's flowering. This is unusual among plants under field conditions.



FIG. 5A. Bulbs from population U, showing fleshy rhizomes.  
 Fig. 5B. Capsules produced by plants of natural populations: a—population U; b, c—population TB; d, e—population CL; f—population QP.



(b) *From study of plants under cultivation.*

The main conclusions derived from the study of plants under cultivation may be summarized as follows.

Plants, from populations that under field conditions flowered without leaves, or with short leaves developed by few plants only, flowered under protected conditions with fully developed leaves. At no time were plants leafless. All leaves died off only when plants were exposed to unusual and extreme cold or excessive dryness.

During the first four and a half years under cultivation (the period indoors), plants bloomed mainly in early spring, only few peduncles being developed at other times. Following the transfer to sunny greenhouse conditions, many plants flowered simultaneously, despite February being late in the normal flowering season. Subsequently, the plants flowered sporadically, few periods existing when no inflorescences were developed by any plants. Specimens from some grassveld populations, KO, KD, (under field conditions the leaves were all under 2 mm wide, while peduncles were mainly 1 flowered) have never flowered under cultivation.

Parameters of leaf width and number of flowers per inflorescence recorded during the whole period of cultivation show that comparatively little change in morphological form occurred within most individual plants under protected conditions. Nevertheless, some general trends could be detected. Plants from narrow leaved populations (DR, OC, KO, KD) showed a slight trend towards increased leaf width, while plants from wider-leaved populations (TS, D, KR) showed either no change (TS), or a trend to narrower leaves (D). Three plants should be specially mentioned. One (KO), the leaves of which at time of collection and under the main period under cultivation never exceeded 2 mm in width, in the seventh year after potting, produced leaves 3.4–4.0 mm wide centrally among the narrow leaves. It has subsequently produced only leaves exceeding 4 mm wide. Two plants (from KR) with leaves that at collection and during the main period of cultivation had been 7–9 mm wide, in spring 1966, produced leaves 13–15 mm wide. These plants have also continued to develop wider leaves.

Where inflorescences were produced under cultivation, flower number per peduncle remained within limits recorded for the same populations under field conditions, except D, where reduction occurred.

It must be stressed that cultural conditions were not ideal. During the first (indoor) period lack of sunlight must have adversely influenced all plants, for in the field they are heliophytes. Availability of plentiful water throughout the year undoubtedly favoured plants from vlei/streambank/stream populations. The uniformity of growing conditions through the year, especially the lack of a cold period, may have contributed to factors governing absence of

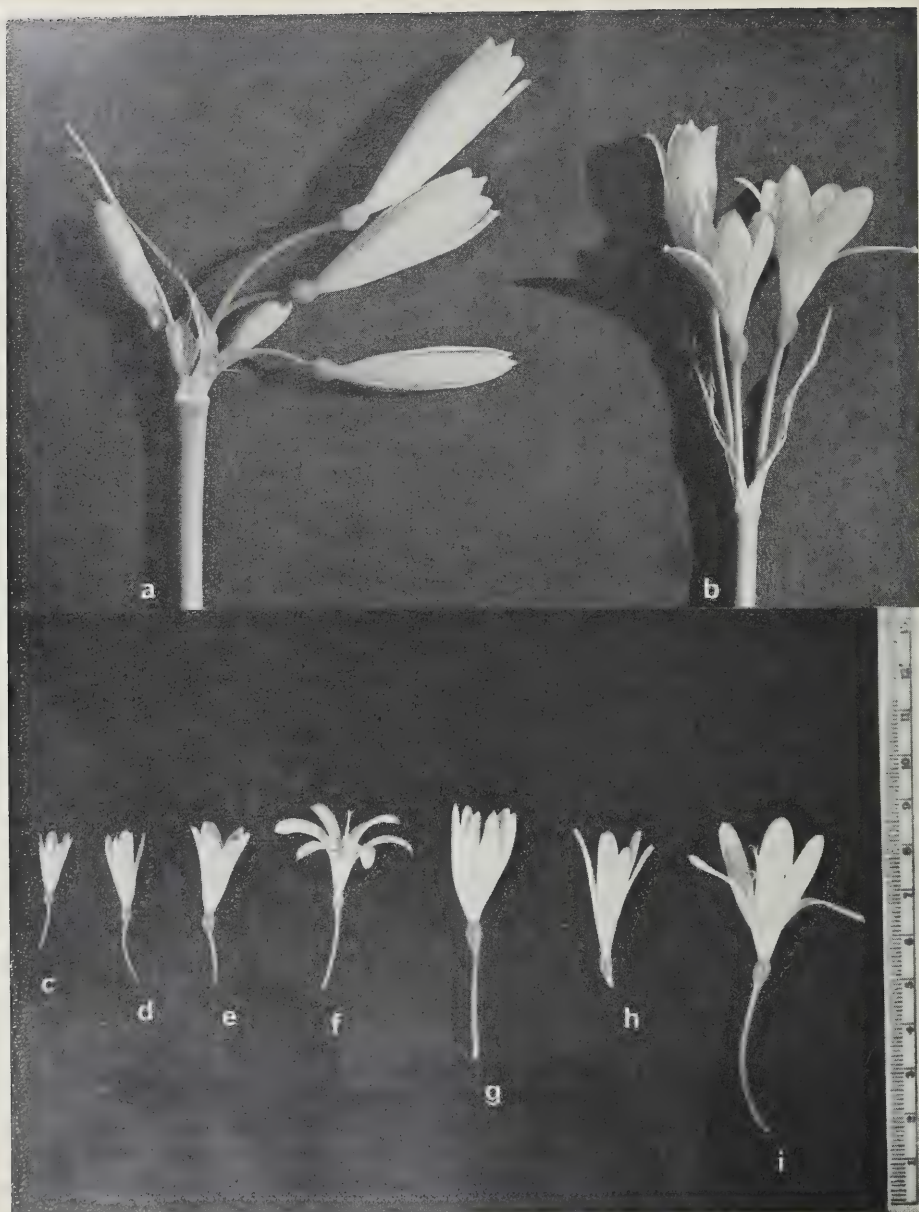


FIG. 6. Perianth form in *Cyrtanthus breviflorus* above—inflorescences from plants of population B, grown a—indoors; b—in garden in full sunlight. Below c—f—flowers from population CL, all of approximately same age; g—from cultivated plant originally from Kokstad; h—from population U; i—from population QP.

inflorescences among plants from what, on inspection, were assessed as drier grassveld habitats.

The intermediate nature of the cultural conditions (more favourable than many natural grassveld situations; less favourable than some vlei/stream/streambank habitats) may have governed the slight trends towards increase in size of narrow leaved plants, decrease in width of widest leaved plants, that were recorded. The three plants that produced markedly wider leaves under cultivation will be considered again later.

While the conclusions drawn above need the substantiation of more extensive, longer and better designed cultivation studies before they can be regarded as conclusive, the present work indicates that parameters of field populations probably do not undergo marked, rapid change under altered environmental conditions. Nevertheless, environment does seem to exert some influence on morphological form.

Plants growing naturally in vlei/stream/streambank populations seem less affected by drier conditions under cultivation than are grassveld populations by wetter ones. Although some reduction in leaf width and in number of flowers to the peduncle did occur under cultivation giving the plant concerned, eventually, a less robust appearance, flowering took place regularly and freely. This was not so with plants from more extreme grassveld habitats grown under more favourable conditions.

The original population sample (B) was large. Some plants were cultivated in pots indoors, others grown in full sunlight under garden conditions. In the third year after planting both groups flowered simultaneously. The differences in pedicel and perianth length and flower form are shown in Fig. 6a, b. Similar differences have also been observed in the field.

Until spring 1967 artificial pollination was not attempted. From 1960 to spring 1967 apparently no natural pollinating agents reached the flowers, for no capsules matured. Thus no seed, nor seedlings, were produced. All increase thus came about by vegetative multiplication. In spring 1967, selfing of approximately twelve flowers from three different populations showed that capsules developed, but died off without maturing seed. Inter-population crossing, on the other hand, produced mature seeds. Further experimentation is needed.

#### DISTRIBUTION

From herbarium specimens the distribution of plants in South Africa was investigated. Plants that satisfied the majority of criteria for plants from vlei/streambank/stream populations were considered as one extreme and localities were plotted (Fig. 7).

Known distribution was found to be confined to eastern South Africa from the Transvaal to the East London area of the Cape Province. Plants

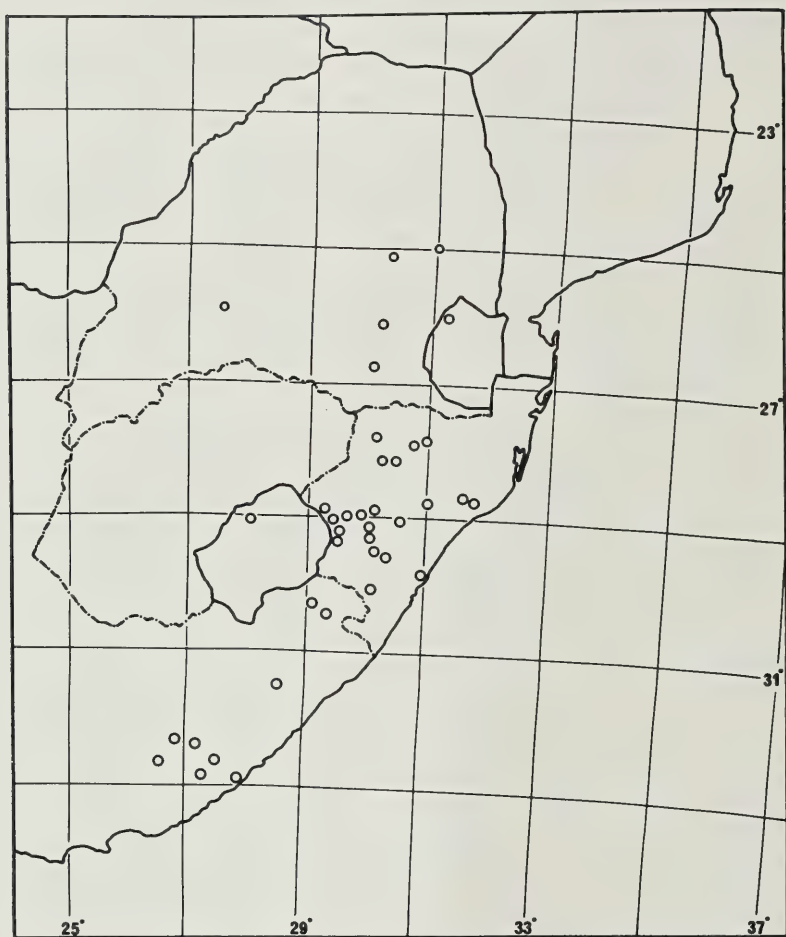


FIG. 7. Known distribution in South Africa of populations satisfying criteria associated with plants from vlei/streambank/stream situations.

occurred as far inland as Rustenburg in the Transvaal and Lesotho (Basutoland). Further south plants were not recorded from so far inland, the known limit being the Katberg (near Alice).

Plants that satisfied the majority of criteria for grassveld populations were considered as a second extreme and localities were plotted (Fig. 8). Distribution

followed closely that of vlei/streambank/stream populations except that no locality was recorded as far inland as Rustenburg, nor Lesotho, nor the mountains near Alice, nor were there records from the eastern Transvaal and Swaziland. However, numbers of records for plants that, in morphological form, could be considered intermediate between these extremes, linked the distribu-

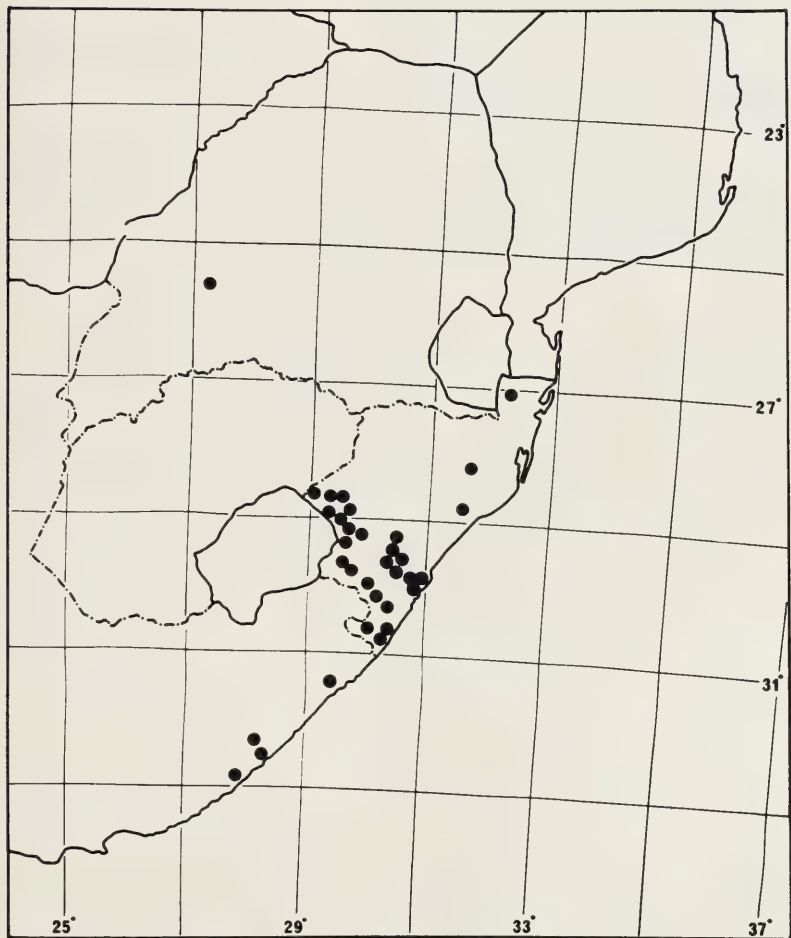


FIG. 8. Known distribution in South Africa of populations satisfying criteria associated with plants from grassveld situations.



tional ranges of the extremes (it was not considered necessary to map the distributional range of the intermediates). Some records are known from Rhodesia and further north in tropical east Africa. All specimens seen from here were of the grassveld type or were intermediate. As doubt exists that the specimens seen were representative of all populations that occur, distribution north of the Limpopo river has not been seriously considered.

In South Africa, the generally similar distributional pattern for both grassveld and vlei/stream/streambank extremes is interesting, especially in view of Medley Wood's earlier finding (see p. 37) which is not now supported by distributional evidence: but his comment that *A. luteus* is "never in swamps" still holds. The maps (Figs. 7 and 8), since they do not indicate local altitude, can be misleading: especially is this so on the Drakensberg. It must be stressed that here, above 1,829 m (6,000 ft) all plants are reasonably robust and of the form associated with vlei/streambank/stream or intermediate situations. No very slender plants of the form associated with drier grassveld situations occur.

#### CHROMOSOMES

Gouws (1949) reported  $2n = 16$  for *Anoiganthus breviflorus* (plants from Wakkerstroom, Transvaal). Ising (1962) stated that, "The chromosome pictures given [by Tjio and Levan (1950)] for *C. lutescens* (*C. mackenii* var. *cooperi*, see Ising, 1966: 27) are in good agreement with the idiogram of Gouws (1949) for *Anoiganthus breviflorus*. Transposing the chromosomes D and E of Gouws as well as F and G, complete correspondence is reached between the two systems". Ising (1964, personal communication to Chief, Bot. Research Inst., Pretoria) stated that he had investigated chromosomes of plants of *A. breviflorus* from different localities. The small type (36C) was most likely collected in Natal. "It has 16 chromosomes which are very similar to the chromosomes of *Cyrtanthus parviflorus*." The larger type (38A) was collected from a small stream at Cathedral Peak (cf. Killick 945 PRE, "occasional along streambank, Cathedral Peak Forest station, Catchment I, 6,100 ft"). This proved to have 32 chromosomes "and is accordingly a tetraploid". Ising (1967, personal communication to Gordon-Gray) stated that the chromosome number of *A. luteus* (plants from near Pigg's Peak, Swaziland) was  $2n = 16$ .

The above statements indicate the close chromosomal relationship between *Cyrtanthus* and *Anoiganthus* and support Wilsenach's merging of the latter genus into the former. They also indicate the need for further careful chromosomal studies among natural populations of plants that could be referred to *C. breviflorus* and *C. luteus*. Killick 945 PRE agrees in structural form with plants from vlei/streambank/stream habitats. Ising did not state specific criteria by which "small type (36C)" *A. breviflorus* was distinguished from *A. luteus*. Presumably differentiation was based on features originally established by Baker,

and later variously modified by others: nor did Ising refer to chromosomal differences between the sixteen chromosomes of his plants of *A. luteus* and the sixteen of *A. breviflorus* "small type (36C)". (Such differences may become apparent when further plants have been studied). Ising's plants of *A. luteus* and of his "small type (36C)" must both have been smaller and less robust than "larger type (38A)", and it is feasible to suppose they could be related to plants considered previously in this paper as from intermediate habitats and from vlei/streambank/stream situations, respectively.

Ising (1967) further stated that he was busy investigating chromosomes of  $F_1$  hybrids between plants 36C and 38A mentioned above. Preliminary results indicated  $F_1$  hybrids possessed  $2n = 24$  chromosomes and were thus triploids.

What is significant, at present, is evidence of the polyploid state among plants with robust morphological form occupying a streambank situation, and evidence of the diploid state among plants with less robust form from intermediate and/or grassveld habitats. This is, however, but a beginning.

#### LEAF ANATOMY

Variation in leaf width among plants and its apparent correlation with habitat conditions, together with reported tetraploidy for a plant with wide leaves from a streambank situation, prompted investigation into leaf anatomy to determine whether marked structural differences existed.

Leaves of plants under cultivation were studied since these were readily available. In summer 1965–66, the widest leaf borne by plants of each of the following populations was cut and immediately preserved in formalin-acetic-alcohol: D (stream/streambank); KD (grassland); DR (relatively dry vlei tending to grassland); M (moist vlei).

Several days later hand sections were cut from the widest part of each blade, which was always between one-third and one-half total length, measured from the base. Sections were placed in 20% glycerine then mounted in safranin jelly.

Transverse sections of leaves are shown in plan (Fig. 9). The only significant structural differences were in the number of vascular bundles present (23 in D, 5 in KD, remainder intermediate) and in the sclerenchyma forming a sub-epidermal cap to the margins of leaves of D and M (the two widest leaves sectioned). Presumably such a marginal strengthening strand is essential in leaves of appreciable width.

All leaves, irrespective of width, showed, in transverse section, a single layered epidermis completely surrounding the leaf and well supplied with stomata ad- and ab-axially. The epidermal cells bounding the leaf margins and the midvein (abaxially only) possessed thicker outer walls than did those of the remaining epidermal cells. Here, too, the exposed cell surface was angular

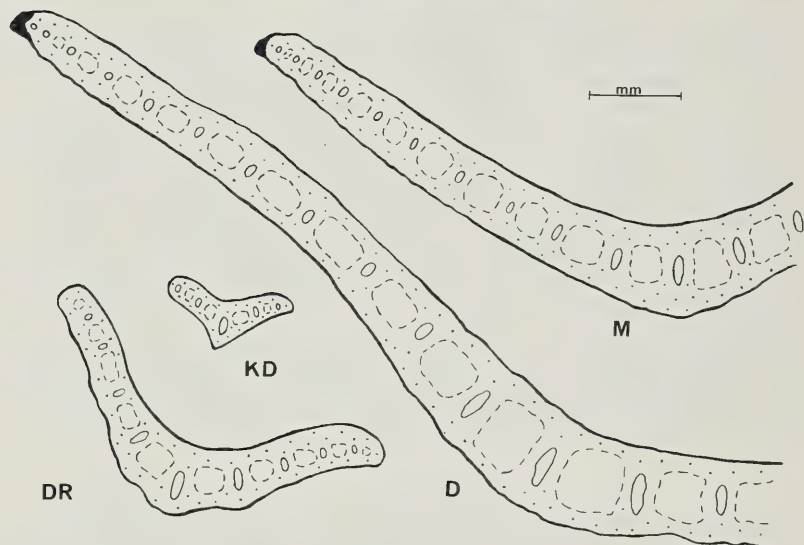


FIG. 9. Plans of transverse sections of leaves of *Cyrtanthus breviflorus* showing general distribution of tissues (stomata omitted): black-sclerenchyma; dotted-chlorenchyma; air-spaces outlined by broken line; vascular bundles outlined by continuous line. Symbols represent populations (see Table 1).

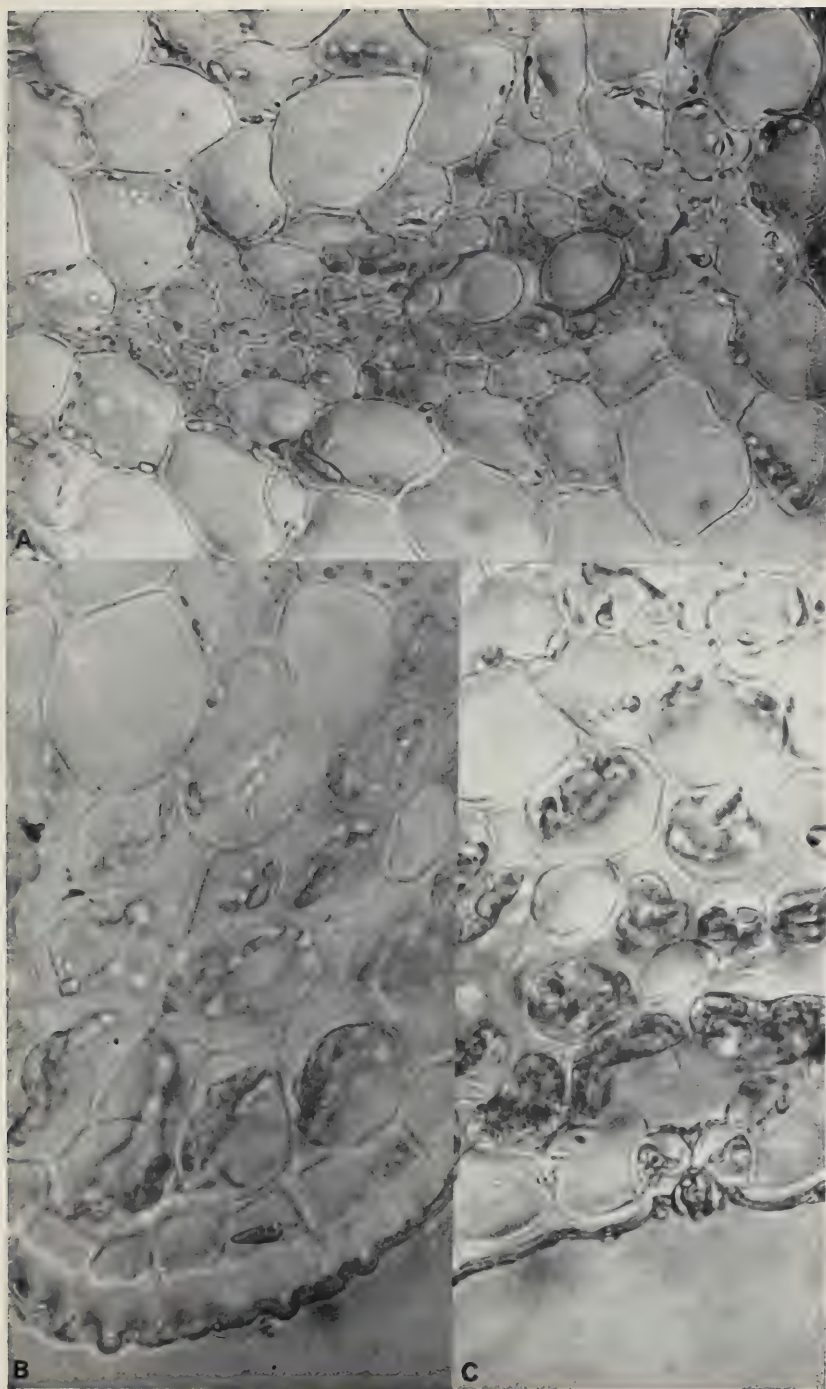
to papillate rather than gently convex (Fig. 10B). A well developed cuticle was discontinuous only over stomatal apertures.

Sub-epidermally a zone of loosely-packed chlorenchyma usually four or five cells in depth (occasionally seven adjacent to the vascular bundles), formed the photosynthetic tissue of the leaf. The depth of this zone did not differ in number of layers of cells, nor in relative proportion in relation to other tissues represented, from wide to narrow leaves.

The remainder of the leaf consisted of vascular tissue and thin walled parenchyma with few chloroplasts which together formed a central region.

The vascular bundles, apart from variation in number, were remarkably uniform consisting of phloem towards the abaxial epidermis with xylem, in which usually one or two metaxylem vessels were clearly defined, situated adaxially. The conducting tissue was surrounded by parenchyma cells of

FIG. 10. Microphotographs of portions of transverse sections of leaves of *Cyrtanthus breviflorus*: A—vascular bundle; B—leaf margin, note thickened outer walls and papillate surface of epidermal cells; C—stomate from abaxial leaf surface, note thinner outer walls of epidermal cells.





approximately the size represented in the chlorenchyma, but containing fewer chloroplasts.

Between the vascular bundles, which thus formed "girders", the soft parenchyma tissues were partially or completely broken to form "air spaces". Such cavities were represented in both wide and narrow leaves, irrespective of habitat, and are probably attributable to rapid longitudinal elongation of the leaf during development, rather than to an hygrophilous environment. It was only between the very reduced vascular bundles towards the leaf margins that the parenchyma was continuous.

Throughout the leaf, in both chlorenchyma and the more or less colourless parenchyma, mucilage secreting cells were frequent, being recognizable by their apparent lack of contents and slightly thickened walls.

#### LEAF EPIDERMIS AND STOMATA

After leaf widths had been recorded, portions of abaxial leaf epidermis were stripped from base, middle and apical thirds of at least three leaves (generally six or more if these numbers were available) of plants under cultivation from the following populations: D, M, KR, KD, KO, DR. Immediately on removal from the leaf surface epidermal tissue was placed in 100% ethyl alcohol, all strips from one population being placed in a single sample tube. The procedure was repeated for the adaxial epidermis.

Leaves were amphistomatic with stomata in parallel rows interspersed among longer, smooth walled epidermal cells. Stomata were without subsidiary cells, the type characteristic of geophytes (Stebbins and Khush, 1961).

Since diploids and polyploids have been reported for *Cyrtanthus* in Natal, stomatal length was measured to determine whether such parameters would aid in distinguishing diploid and polyploid populations. Preliminary measurements showed that abaxial stomata were slightly longer than the adaxial. Consequently abaxial stomata only were considered. Five epidermal strips taken at random from each sample tube were mounted, cuticular surface outermost, and the lengths of four stomata taken at random anywhere on the strip measured by means of a micrometer eyepiece. The twenty stomatal lengths thus obtained were taken as representative of the plants of a particular population under cultivation. Extremes and means for each population are given in Table 4 together with mean widths of leaves stripped. On statistical analysis, parameters showed no significant variation in stomatal length, but high significance between populations ( $F = 66.8$ ; d.f. 114). Populations could not readily be grouped, however, but showed obvious correlation with mean leaf width (Table 4).

D and KR, on morphological form and habitat preferences, are suspect polyploids, while KD, with its narrow leaves and grassveld situation, is suspect



TABLE 4

Extremes and means of stomatal lengths (abaxial epidermis), and mean leaf widths of *Cyrtanthus* leaves stripped for epidermal study: plants under cultivation.

Population	Stomatal Length in microns		Mean Width for Leaves stripped in mm
	Extremes	Mean	
KR	57.04—75.20	66.27	11.5
D	48.79—61.03	53.79	6.7
M	44.69—58.92	49.23	4.0
KO	33.86—54.70	46.61	3.9
DR	35.08—55.98	44.28	2.7
KD	37.93—46.60	41.99	1.2

diploid. Stomatal length does not clearly indicate in which of these groups the other measured populations fall. Dimensions of pollen grains have not yet been assessed. Such parameters may prove more revealing in the separation of tetraploids and diploids than was stomatal length.

#### DISCUSSION AND TAXONOMIC CONCLUSIONS

The specimens on which Harvey based *Cyrtanthus breviflorus*, with broad leaves contemporary with the several flowered umbellate inflorescence, are morphologically clearly distinguishable from Baker's description of his type of *C. luteus*. Field study has shown that broad-leaved populations relating to Harvey's type occupy vle/streambank/stream habitats from low to high altitudes, while populations relating to *C. luteus* occupy damp to drier grassveld situations from low to high altitudes (not above 1,829 m in Natal, but this elevation may well be exceeded further north). Field study has also shown that between these extremes populations occupying intermediate habitats and comprising plants intermediate in morphological form, are frequent.

Careful study in the field, under cultivation, and in the herbarium, has revealed no satisfactory group of correlated morphological differences that represent a discontinuity between *C. breviflorus* and *C. luteus*: rather do the populations and the individuals they comprise, represent a continuous range of gross morphological diversity. Leaf anatomy and stomatal length also provide no clear cut basis for segregation.

What of other aspects of differentiation? Ising's work has revealed that tetraploids and diploids are represented within *C. breviflorus* (large type 38A and small type 36C, respectively), while *C. luteus* is also diploid. At present, any differences in chromosome morphology that exist between *C. breviflorus* (small type) and *C. luteus*, have not been fully documented, but Ising suggests from preliminary work (personal communication to Gordon-Gray, 1967), that

it is likely three chromosomal races, two diploid and one tetraploid will be shown to exist within *C. breviflorus*/*C. luteus*. This would not be surprising, since there are numerous documented examples of intraspecific chromosomal races (Davis and Heywood, 1963; Lewis, 1967).

From the present limited evidence, it seems that plants of stream/stream-bank and really wet vlei habitats may constitute the tetraploid race, while plants of damp and drier grassveld situations and of habitats intermediate between the two extremes named, may represent the two diploid races, all three races occupying a general common area of distribution in eastern South Africa.

This may, however, be an over simplification. As Ising questions, do triploid populations occur naturally? *Cyrtanthus* plants do possess the capacity for vegetative multiplication and thus triploids could propagate mitotically, but from documented examples in the literature, it seems the establishment of triploid populations in nature is uncommon. It is probable that plants comprising a single population may represent more than one ploidal level, for amongst the Angiosperms, the dicotyledons in particular, evidence is accumulating to indicate that diploids and polyploids may co-exist, exhibiting in this co-existence, very little, or no, morphological differentiation and not necessarily requiring distinct ecological niches (Lewis, 1967). It is in this connection, in particular, that attention is again directed to the apparent relationship between morphological form and habitat conditions within *C. breviflorus*/*C. luteus*, so strongly suggested by field study and dealt with earlier in this paper.

Another question remains to be answered. Will all the polyploidy prove to be autopolyploidy having arisen by duplication of the genome? In this connection the production of markedly wider leaves by three plants under cultivation is of interest and perhaps of some cytological significance. Is allopolyploidy also involved? Did the two diploid chromosomal races (?) *C. breviflorus* (small type) and *C. luteus*, or their earlier antecedent(s) (?), produce hybrid progeny which, their fertility restored by chromosomal doubling, were enabled effectively to exploit wet vlei/streambank/stream situations unsuitable for the diploid races, but in close proximity to habitats occupied by them?

Whatever evidence further cytological work discloses, and it is clear that interest attends this, the problem of how to apply the names of *C. breviflorus* and *C. luteus* to plants exhibiting a continuous range of gross morphological diversity, remains for the practising taxonomist. Since no clearly defined discontinuity based on correlated morphological criteria exists within the series, both names cannot continue in use. *C. luteus*, the more recent, must be sunk. Baker, 1888, himself recognized the need for this by assigning *C. luteus* varietal rank under *Anoiganthus*. At the present stage of knowledge, the recognition of intra-specific categories within *C. breviflorus*, is not meaningful. Criteria that would effectively permit differentiation between the robust wide-leaved plants

of wet vle/streambank/stream situations (variety 1) and the slender, narrow-leaved plants of drier grassland habitats (variety 2), could readily be formulated, but so numerous and varied are the intermediates between these extremes, that limits for the two varieties (or three were one to be recognized for the intermediates) would be arbitrarily applied and differently so, by different workers. It seems far preferable to await the results of further chromosomal investigation which, it is hoped, will establish more clearly the nature and the distributional, ecological relationships of the chromosomal races represented intraspecifically, than to append additional epithets not precisely representative of the situation in nature, nor particularly helpful to taxonomist or geneticist.

#### ACKNOWLEDGEMENTS

The authors wish to express their gratitude to the Curators of Herbaria who kindly permitted the loan of specimens for study. Grateful thanks are also extended to all, too numerous to mention personally, who aided in this investigation either by providing plants for study and cultivation, or by permitting study of populations on their property. The authors are much indebted to Mr. D. Tunnington of Dept. of Botany, for his careful photography. Lastly thanks are due to the Council of Scientific and Industrial Research for the provision of part time assistance: to Professors in charge of the Dept. of Chemistry for greenhouse facilities: to Profs. A. W. Bayer and C. H. Bornman, successive heads of the Dept. in which the work was carried out, and to Dr. G. Ising, University of Lund, Sweden, and Mrs. A. A. Mauve, Botanical Research Institute, Pretoria, for helpful comments on the original manuscript.

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#### BOOK REVIEW

BOTANICO—PERIODICUM—HUNTIANUM—Ed. George H. M. Lawrence, A. F. Gunther Buchheim, Gilbert S. Daniels, Helmut Dolezal. Published by Hunt Botanical Library, Pittsburgh, Pa. 1968, 1,100 pages buckram binding \$30.00.

This tome lists some 12,000 titles from the world's periodical literature in plant sciences and has developed out of the studies made for *Biographia Huntiana* by the Hunt Botanical Library staff. It certainly is a most valuable contribution to have all the botanical (pure and applied) periodicals, representing 45 languages, in one volume.

The editors stress that they have chosen the abbreviations used partly to avoid any possible ambiguity and partly on preponderance of usage. At the same time, due consideration has been given to the American standard for periodical abbreviation and the World List of Scientific Periodicals. However, it is distressing to find yet another set of abbreviations differing from those with which we are familiar. Many familiar South African journals have "new" and, I feel, unnecessary abbreviations. For instance, *J. S. Afr. Bot.* becomes *J.S. African Bot* and *Jl S.Afr. biol. Soc* is *J.S. African Biol. Soc.* The lists appear very comprehensive, but as is often the case the purely Afrikaans journals escape notice, e.g. *Tydskrif vir Natuurwetenskappe* is not listed.

There are two very useful appendices, one listing the abbreviations of words used in the B-P-H and the other giving political chronology for place names. This is so essential when place names change as is often the case with change of regime.

The cross-references in the main text are excellent, making it easy to find one's way around in the book.

E. P. DU PLESSIS.





# JOURNAL OF SOUTH AFRICAN BOTANY

VOLUME 35, PART 2

Published: 15TH MARCH 1969

## THE VOLUME "*ICONES PLANTARUM ET ANIMALIUM*" IN THE AFRICANA MUSEUM, JOHANNESBURG; AND ITS RELATIONSHIP TO THE *CODEx WITSENII* QUOTED BY JAN BURMAN IN HIS "*DECADES RARIORUM AFRICANUM PLANTARUM*"

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### ABSTRACT

'*Icones plantarum et animalium*', a magnificent volume of 17th Century water-colour paintings, is somewhat of an enigma for there are no original headings signatures or dates. 'I.P.A.' includes over 300 studies of Cape Plants, and has been justly described by Kennedy, in his introduction to the "Catalogue of pictures in the Africana Museum" vol. 2, as of great importance in the history of South African Botany. The acquisition of this volume by the Africana Museum, and its subsequent recognition as a possible source for many of the figures in the '*Decades*' ends a widespread search in recent times for such a volume in the series of Dutch natural history paintings known as the *Codex Witsenii*.

### THE WITSEN CODEX

A vivid picture of the times and circumstances in which the Codex was compiled can be drawn from the writings of Waterhouse (1932), White and Sloane (1937), White, Dyer and Sloane (1941), Karsten (1939-1946, 1951, 1963-1967), Hutchinson (1946), Barnard (1947), Reynolds (1950), Smith (1952), Vogts (1958), Lighton (1960), Edwards (1964), Jessop (1965) and Kennedy (1967).

They tell of Heurnius, Hermann and other early explorers at the Cape, who brought back some of the bizarre and beautiful plants they encountered, returning to Leyden and other cities with material to stimulate the enthusiasm for the world of nature that was sweeping through Europe at that time. Oldenland and Hartog, Superintendents of the Dutch East India Company's Garden

Accepted for publication 18th June, 1968.

at the Cape, tended the wild plants gathered from far and near. These dedicated men propagated, pressed, preserved, described and catalogued an ever increasing collection of indigenous species, sending living material, seeds and information to the gardeners and botanists of Europe, where these plants were highly prized. Burman in 1737 published a catalogue of the plants collected by Hermann, Oldenland and Hartog as an appendix to his 'Thesaurus Zeylanicus'. Many of these are found in 'I.P.A.'

Herman Boerhaave, following Justus Heurnius and Paul Hermann at Leyden University, partook of their keen interest in the flora of South Africa. They passed on this enthusiasm to their pupil, Nicolaas Witsen. As a Director of the Dutch East India Company, and a trustee of the Hortus Medicus in Amsterdam, the illustrious Witsen was in a position to build up the collections of exotics in the Gardens and Herbarium. With the help of Jan Commelin and his nephew, Caspar Commelin, Witsen developed the Hortus Medicus in the tradition of the famous Gardens of Leyden.

Witsen commissioned the painting of the Cape and Batavian Floras, and some of this was done at the Cape from fresh material. Hendrik Claudius, apothecary and artist, portrayed plants and animals with fidelity. Tachard, the French Jesuit, and van Rheede tot Drakenstein, botanist and Company official, saw him at the Cape and took some of his work back to Europe. 'I.P.A.' has several distinct groups of pictures, probably done by different artists at different times. Some of the finest may be attributed to Claudius, and Kennedy catalogues the 'I.P.A.' paintings under his name.

Copies of the Codex pictures were made for favoured recipients: Compton, Bishop of London was given 100 studies of South African plants. Several sets of the series covering the famous expedition of Simon van der Stel to Namaqualand are known. 'I.P.A.' includes this series. A volume 'T.C.D.' in Trinity College, Dublin was described by Waterhouse (1932), and a similar one, 'S.A.M.' in the South African Museum, Cape Town by Barnard (1947). These and some unbound sheets in the S.A. Public Library, Cape Town, belong to the Namaqualand series. A companion volume to 'S.A.M.' in Pretoria was described by Jessop (1965). This has Cape flowers and no copies are known. Oostroom (1951) has reproduced studies of *Proteaceae* in Leyden that are replicas of 'I.P.A.' paintings. The Leyden sheets are presumed to be some of the originals used by Boerhaave for illustrations in his 'Index Alter Plantarum' (1720). Vogts (1958) considered the 'I.P.A.' paintings as possible prototypes for Boerhaave's figures (I.P.A. has almost all Boerhaave's *Proteaceae*), but some are simplified, and probably were copies made for Witsen to take to Amsterdam. Paintings of the Codex series are also housed in the British Museum, London, and other parts of the world. Boerhaave estimated there were over 1,500 paintings in the Witsen Codex.



Fig. 1. *Cinnamomum camphora* Nees and Eberm. "I.P.A." fol. 66.



Fig. 2. *Datura metel* L. "I.P.A." fol. 39.

Paintings in "I.P.A." of plants from the East, introduced to the Cape before 1700.



Fig. 3. *Maytenus acuminatus* (L.f.) Loes. Note badly-drawn inflorescence, matching "Decades" t. 97 fig. 3. "I.P.A." fol. 209.



Fig. 4. *Podocarpus latifolius* Thunb. Female inflorescence only, matching "Decades" t. 93. "I.P.A." fol. 73.

Species in "I.P.A." with corresponding illustrations in Burman's "Decades", not cited in Linné's "Species Plantarum".

Illustrations of South African plants matching paintings in the Codex have been recognised in various books. Tachard (1687) has a few of the Namaqualand series. Commelin (1701), adding an inflorescence to his picture of *Aloe plicatalis* Mill. grown in the Hortus Medicus, says it was taken from the Witsen Codex. This inflorescence can be matched with 'I.P.A.' fol. 5. Figures in the works of the two British botanists, Plukenet (1691-6) and Petiver (1702-9) are apparently formalised versions of Codex paintings. Weinman (1737), like Boerhaave (1720), had copies of Codex *Proteaceae* in his book; Burman (1738) has over 90 figures corresponding with 'I.P.A.' paintings; Breyn has figures like some in the Pretoria volume, and there is a *Euphorbia* picture taken from the Codex in an unidentified work of Buchoz (circa 1739). The illustrations are usually copper-plate engravings, reversed in printing, often simplified or made artistically more acceptable, leading in some cases to errors of interpretation. Weinman's pictures are hand-coloured and a good match of 'I.P.A.' colours except that his reds have preserved better than some in 'I.P.A.'.

Jan and Caspar Commelin were given custody of the Codex by Witsen, and after the death of Jan Commelin and Witsen, they were retained by Caspar until he too died. His widow gave three large volumes of the series to the young Amsterdam botanist Jan Burman who was quite overcome with this unexpected honour. They were kept and used by him and his son Nicolaas, but were eventually sold by Jan's grandson and lost to science.

Jan Burman's 'Thesaurus Zeylanicus', besides the Catalogue of Cape plants, has on the back of the last page an incomplete alphabetical list of exotics growing at the Cape. This includes the species *Datura metel* L. and *Cinnamomum camphora* Nees & Eberm., both beautifully illustrated in 'I.P.A.' and both annotated as Indian species. (Plate 1 figs. 1 and 2.) Nicolaas Burman in his 'Flora Indica' (1768) illustrates *Sium ninsi* L. with a figure t.29 Fig. I matching two uncoloured sketches fols. 280 and 282 in 'I.P.A.'

#### THE 'DECADES' AND THE CODEX

Jan Burman published the 'Decades' about 6 years after he received the three Codex volumes. He described and figured over 200 species of South African plants, and his text has frequent mention of the Codex. In the 97 plants associated with the Witsen Codex he also often refers to information in the Manuscript Catalogue of the Witsen Codex, prepared for Witsen by Caspar Commelin, and in most cases the figure in the 'Decades' can be matched with a painting in 'I.P.A.'. Certain species are related to a 'van der Stel Collection' of paintings. Many of the remaining species were described from material in the Witsen Herbarium, and where no clue is given, one often infers they were from this source; however they may have been described and figured from one of the Codex volumes without acknowledgement. It does not appear that





Fig. 5. *Celtis africana* Burm. f.: "I.P.A." fol. 72: "Decades" t. 88.



Fig. 6. *Oxalis pes-caprae* L.: "I.P.A." fol. 259: "Decades" t. 74.



Fig. 7. *Euclea racemosa* Murr.: "I.P.A." fol. 258: "Decades" t. 84 fig. 1.

Paintings in "I.P.A." with corresponding figures in Burman's "Decades". These figures are types of the species.

his pictures and his information were always taken from the same source. Sometimes he would say a plant was 'elegantly depicted' in a certain volume; more often he referred only to the notes accompanying the paintings, relating this information to descriptions in the works of Tournefort, Plukenet and many others.

The Waterhouse description of the volume 'T.C.D.' aroused interest in 'S.A.M.' as a possible source of some of Burman's illustrations in the 'Decades'. Dr. Luckoff looked for a painting to match a figure of *Stapelia variegata* L. in the 'Decades', described by Burman as beautifully illustrated in the van der Stel Collection. White & Sloane (1937) note that none was found. Barnard (1947) found 12 paintings in 'S.A.M.' to match 'Decades' figures associated with the Witsen Codex. He estimated that 92 came from this source and voiced the question where the remaining 70 paintings might be. Jessop (1965) noted that the volume in Pretoria had 6 paintings to match 'Decades' figures. One was the missing picture of *Stapelia variegata*; this and 4 others were associated with the van der Stel Collection, and one, *Oxalis purpurea* L. with the Witsen Codex. About 30 of Burman's plants were linked with the van der Stel Collection, so Jessop concluded the Pretoria volume was not the one mentioned by Burman.

Jessop, considering the possibility that 'I.P.A.' might be equated with the Witsen Codex quoted by Burman, drew attention to certain discrepancies between them. A few of Burman's plants with quotations from the Witsen Codex cannot be matched in 'I.P.A.'. There are about 4 that can be matched, but which are associated with the van der Stel Collection and not with the Witsen Codex, and there are many cases where 'I.P.A.' lacks some or all of the information quoted from the Codex. These differences can be explained if one assumes Burman had duplicate sets of parts of the Codex series at his disposal, not all with identical notes, and that his reference to the Witsen Codex applied to the whole work, in the sense used by Boerhaave: Only in the case of the van der Stel Collection was he referring to a particular volume. Mention of the Codex in relation to a certain plant would then imply that a painting was present, but the figure and the notes could have come from different paintings of the same species. The remarkable thing is that there is so much agreement—about 95% of the Decades figures and 60% of the notes associated with the Witsen Codex could have been taken from 'I.P.A.'. With this wider concept of the Witsen Codex in mind, we can look afresh at the status of 'I.P.A.' as possibly one of the volumes used by Burman for the 'Decades'.

Where 'I.P.A.' lacks an exact counterpart of a 'Witsen Codex' figure, an alternative painting of the species can be found: *Oxalis purpurea*, t.27 fig. 3 in the 'Decades' matches the painting in the Pretoria volume and not the one of this species in 'I.P.A.', fol. 138, but words quoted from the Codex correspond

with those on the 'I.P.A.' sheet. Two species of *Cryptadenia* have figures in the 'Decades' unlike 'I.P.A.' paintings of the same species. Here again the notes quoted from the Codex are the same as those in 'I.P.A.'.

As evidence of duplication of material in the various Codex volumes, in the description of *Lobelia erinus* L., Burman refers to both the van der Stel Collection and the Witsen Codex. His figure, t.40 fig. 1 matches 'I.P.A.' fol. 255, but was copied from the van der Stel Collection. (Plate 3, fig. 8). When mentioning this Collection, he sometimes added that these paintings were done from living material at the Cape. He would have used these in preference to copies in another volume. This might account for the presence in 'I.P.A.' of these 'Decades' pictures, linked with the van der Stel Collection, and not with the Witsen Codex:—*Pelargonium myrrhifolium* (L.) Ait., t.37 fig. 1 in the 'Decades' with a poor copy in 'I.P.A.', fol. 263:—*Rhus lucida* L. t.91 fig. 2 like fol. 254:—*Cliffortia ruscifolia* L. t.98 fig. 3 like fol. 224, and *Berzelia abrotanoides* L. t.100 fig. 1 like fol. 20 in 'I.P.A.'. Notes are limited to a tentative name or absent in the first 3 in 'I.P.A.'. Only in the last is there information one might have expected Burman to quote.

Two of Burman's references to the Witsen Codex are difficult to relate to a particular painting in 'I.P.A.'. *Phylica stipularis* t.43 fig. 2 is said to be unlike the plant in the Witsen Codex. The only *Phylica* in 'I.P.A.' is *P. plumosa* L. fol. 219. It is clearly not this picture to which he refers. The other species is *Microlooma tenuifolia* (L.) K. Schum., described and figured twice in the 'Decades'. Notes from the Codex and t.15 correspond with 'I.P.A.' fol. 155, but t.16 fig. 1 cannot be matched. These two species were probably taken from a different series to the ones in 'I.P.A.'.

While an appropriate painting can be found to match all save these two plants, there are many cases where information quoted from the Witsen Codex cannot be found in 'I.P.A.'. This is most noticeable in the Namaqualand series. Of 12 plants in the 'Decades', only 3 have wording that agrees completely with 'I.P.A.'. Most of the others correspond with 'S.A.M.', a volume known to have been in Burman's possession at some period, for the notes in it are in his handwriting.

Information was added to the 'I.P.A.' sheets, apparently, on two occasions, first the name and flower colour in a faded ink, then details of locality and time of flowering in a darker ink but the same writing. Apart from the Namaqualand plants, there are about 15 cases where 'I.P.A.' lacks some or all of the information given from the Codex, usually from this latter part of the notes. Alternative paintings of all these must have been in existence. Some conflicting information may be due to corrections of obvious errors: the yellow-flowered *Zygophyllum morganiana* L. fol. 144 called 'coerulea' in 'I.P.A.' is quoted from the Codex as



Fig. 8. *Lobelia erinus* L. Differs from "Decades" t. 40 fig. 1 in having serrate-edged leaves.

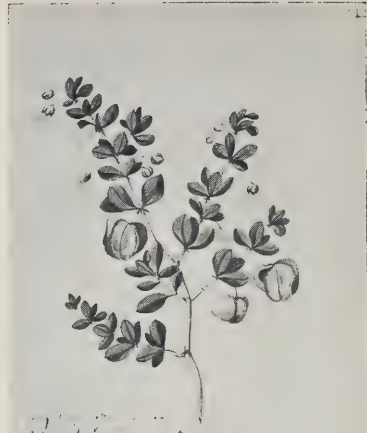


Fig. 9. *Zygophyllum morskana* L. Flowers erroneously described as blue on "I.P.A." fol. 144: Correctly called yellow in "Decades" text with t. 3 fig. 2.



Fig. 10. *Cotyledon ventricosa* Burm. f., "I.P.A." fol. 13, matching Burman's t. 21 fig. 1 in the "Decades".



Fig. 11. *Salvia africana-lutea* L. "I.P.A." fol. 42. One of the many beautiful paintings in the Codex not utilised by Burman in the "Decades": The species was described and illustrated by Commelin from material in the Hortus Medicus, Amsterdam.

Paintings of interest in "I.P.A."



'flava'. (Plate 3, fig. 9). The only inexplicable reference in the 'Decades' is to *Oxalis versicolor* L., the lower picture of fol. 257. It has in 'I.P.A.' notes of flower colour, locality and time of flowering, while Burman says that in the Witsen Codex it is not annotated.

There is no indication whether or not 'I.P.A.' was one of the volumes given by Caspar Commelin's widow to Burman, but the contents point to the probability that it was used by him in the 'Decades' at the same time as 'S.A.M.' and the volume in Pretoria. It is to be hoped that the van der Stel Collection and the Manuscript Catalogue of the Witsen Codex by Caspar Commelin, like 'I.P.A.', 'S.A.M.' and the Pretoria volume, have escaped destruction over the centuries, and that they too will sometime come into the hands of people who appreciate their historical and scientific value.

#### CARL LINNÉ AND THE CAPE FLORA

Three years before the first part of the 'Decades' was published, Burman was glad to enlist the help of a young Swedish botanist commended to him by Boerhaave and others at Leyden University. This was Carl Linné who spent a year in Amsterdam, receiving free board and lodging in Burman's home in exchange for assistance with the collections of exotics in the Amsterdam Gardens and Herbarium. Linné must have studied the venerated Codex volumes with care in that year when visions of a new system for the naming, identification and classification of all plants of the World were crystallising in his mind.

Many 'Decades' plants appear in Linné's 'Species Plantarum' (Ed. I 1753). As he knew Burman's book so well, any omissions may well have been deliberate: for example, *Maytenus acuminatus* (L.f.) Loes., badly drawn in 'I.P.A.' fol. 209, is shown in the 'Decades' with flowers scattered down the stem and not in axillary clusters as they should be (Plate 1, fig. 3). Linné did not quote this figure nor describe the species. In another category is the unmistakable picture of *Podocarpus latifolius* Thunb., fol. 73 in 'I.P.A.' and t.93 in the 'Decades'. This was a female branch, and Linné may have required male cones before it could be adequately described. (Plate 1, fig. 4).

Linné was unable to visit the Cape himself, but his pupil Karl Peter Thunberg travelled extensively in South Africa, finding many plants overlooked by the earlier collectors. His 'Prodromus Capensis' (1794) and 'Flora Capensis' (1807-23) include many species in 'I.P.A.' but not in the 'Species Plantarum', and *Podocarpus latifolius* is one of these. Miller in Britain and Linné himself added many new species to the Cape Flora in their later publications. Nicolaas Burman (1768) also a pupil of Linné, listed many new and old species using the Linnaean system of classification, and giving them binomials in his 'Prodromus Capensis'. It is probable that almost all the plants of Hermann, Oldenland,





Fig. 12. *Protea scolymocephala* Reich., "I.P.A." fol. 25, a beautiful painting, possibly original.



Fig. 13. *Protea lepidocarpodendron* (L.) L., "I.P.A." fol. 31, similar in style to fol. 25.

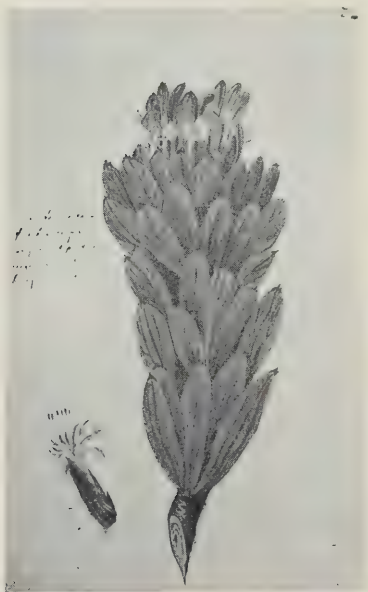


Fig. 14. *Mimites hartogii* R. Br. "I.P.A." fol. 32, in series with the preceding two paintings, but inferior in execution.



Fig. 15. *Protea cynaroides* Thunb. "I.P.A." fol. 215, One of the series with some duplicates in Leyden. The style of painting differs from fol. 25, in "I.P.A." these are probably copies of the originals.

Some paintings of Proteaceae in "I.P.A." Corresponding with illustrations in Boerhaave's "Index Alter Plantarum"; without duplicate paintings in Leyden University.

Hartog, those in 'I.P.A.' and in the 'Decades' were named and described in the lifetime of Linné, and soon after. 'I.P.A.' species given below with authors of more recent times may be wrongly identified, or there may be confusions in modern nomenclature.

#### THE SPECIES IN 'I.P.A.'

Some figures in the 'Decades' taken from the Witsen Codex have been made types for the species. Pothill (1964) selected t.88, Burm., Pl. Afr. as the type for *Celtis africana* Burm. f., while Salter (1944) gives t.74 of Burmann Afr. for *Oxalis pes-caprae* L., and de Winter gives the type of *Euclea racemosa* Murr. as t.84 f. 1 of Burm., Rar. Pl. Afric. (Plate 2, fig. 5, 6, 7). The presence of the originals or copies of them, with the colours of the living plants, enhances the value both of these types and of the 'I.P.A.' paintings from which they were possibly taken. There may be other cases where Codex pictures are the proto-types of recognised type figures.

Where a figure taken from the Codex is quoted in literature, it is possible to give the species of the 'I.P.A.' painting with certainty. This applies to most of the *Proteaceae*, the *Stapelieae*, the *Succulent Euphorbieae*, *Ranunculaceae*, *Zygophyllaceae* and many other individual genera and species. It was fortunate that Dr. Reynolds saw the *Aloe* species in 'I.P.A.' before his death, and that Kennedy was able to publish his determinations. Identifications of some *Proteaceae* by Ion Williams unfortunately missed publication.

The following list is given in Families of plants for the convenience of specialists, for there remains much research to be done on the use made of these paintings by early authors, and citations of these figures in early and later literature.

#### ACKNOWLEDGEMENTS

Dr. Joyce Lewis saw black-and-white photographs of the 'I.P.A.' paintings before she died, and we would like to take this opportunity of expressing our gratitude for the help given by her and Miss W. F. Barker of the Compton Herbarium, Kirstenbosch, with identifications of the Iridaceae and many of the 'difficult' pictures. Our thanks also go to Miss M. Gunn, Librarian of the Botanical Research Institute, Pretoria, for her wise guidance and selfless assistance.

We would like to thank Miss Anna Smith and Mr. R. F. Kennedy of the Africana Museum, Johannesburg for permission to reproduce photographs of the 'I.P.A.' paintings and according us the privilege of working on 'I.P.A.', and to express, on behalf of the botanists of South Africa, appreciation of their service to Science in the publication of a catalogue, with sepia reproductions, and references to corresponding pictures in literature, of all the paintings in 'I.P.A.'.

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- THE CODEX WITSENII

Fol. No.		Fol. No.	
	PODOCARPACEAE		
73	<i>Podocarpus latifolius</i> (Thunb.) R.Br. ex Mirb.	177	<i>Haworthia retusa</i> (L.) Haw. var. <i>retusa</i>
	TAXACEAE	176	<i>Haworthia submaculata</i> van Poelln.
283	<i>Torreya</i> sp. (Exotic)	320	<i>Albuca altissima</i> Dryand
	PINACEAE	272	<i>Albuca fragrans</i> Jacq.
130	<i>Widdringtonia cupressoides</i> (L.) Endl.	325	<i>Ornithogalum suaveolens</i> Jacq.
	CYPERACEAE	307	<i>Veltheimia glauca</i> Jacq.
171	<i>Sickmannia radiata</i> (L.f.) Nees	268	<i>Lachenalia ?glauca</i> Jacq.
	LILIACEAE	321	<i>Lachenalia hirta</i> Thunb.
278	<i>Wurmbea spicata</i> (Burm.) Dur. & Schinz var. <i>spicata</i>	134	<i>Lachenalia pendula</i> Ait.
319	<i>Wurmbea spicata</i> (Burm.) Dur. & Schinz var. <i>spicata</i>	316	<i>Asparagus capensis</i> L.
271	<i>Bulbine alooides</i> (L.) Willd.	35	<i>Asparagus exuvialis</i> Burch.
8	<i>Kniphofia uvaria</i> (L.) hook. f.	36	<i>Asparagus ?thunbergensis</i> Schult. f.
289	<i>Aloe arenicola</i> Reynolds		AMARYLLIDACEAE
3	<i>Aloe brevifolia</i> Mill. var. <i>brevifolia</i>	135	<i>Haemanthus ?rotundifolius</i> Gawl
2	<i>Aloe brevifolia</i> Mill. var. <i>depressa</i> (Haw.) Bak.	53	<i>Haemanthus undulatus</i> Herb.
290	<i>Aloe dichotoma</i> Masson	139	<i>Amaryllis belladonna</i> L.
184	<i>Aloe falcata</i> Bak.	324	<i>Brunsvigia appendiculata</i> Leighton
185	<i>Aloe falcata</i> Bak.	266	<i>Empodium plicatum</i> Bak.
174	<i>Aloe ferox</i> Mill.	330	<i>Walleria armata</i> Schltr.
175	<i>Aloe ferox</i> Mill.		IRIDACEAE
179	<i>Aloe glauca</i> Mill.	109	<i>Moraea ?bituminosa</i> (L.f.) Ker
1	<i>Aloe humilis</i> (L.) Mill.	108	<i>Moraea decussata</i> Klatt
291	<i>Aloe khamiensensis</i> Pillans	107	<i>Moraea edulis</i> (L.f.) Ker
288	<i>Aloe melanacantha</i> Berger	111	<i>Moraea edulis</i> (L.f.) Ker
4	<i>Aloe plicatalis</i> (L.) Mill.	112	<i>Moraea edulis</i> (L.f.) Ker
5	<i>Aloe plicatalis</i> (L.) Mill.	305	<i>Moraea edulis</i> (L.f.) Ker
187	<i>Aloe ?saponaria</i> (Ait.) Haw.	110	<i>Hexaglottis flexuosa</i> Sweet
180	<i>Aloe ?succotrina</i> Lam.	116	<i>Aristea capitata</i> (L.) Ker
181	<i>Aloe ?succotrina</i> Lam.	117	<i>Aristea capitata</i> (L.) Ker
6	<i>Gasteria disticha</i> (L.) Haw.	161	<i>Aristea</i> sp.
186	<i>Gasteria disticha</i> (L.) Haw.	119	<i>Ixia ciliaris</i> L.
182	<i>Haworthia herbacea</i> (Mill.) Stearn	114	<i>Ixia bulba</i> Vent.
7	<i>Haworthia ?integra</i> van Poelln.	115	<i>Tritonia crispa</i> Ker
172	<i>Haworthia margaritifera</i> (L.) Haw.	318	<i>Tritonia crispa</i> Ker
173	<i>Haworthia pallida</i> Haw. var. <i>pallida</i>	113	<i>Tritoniopsis parviflora</i> (Jacq.) Lewis
178	<i>Haworthia ?papillosa</i> (Salm.) Haw.	323	<i>Abiana tubata</i> Sweet
		304	<i>Gladiolus alatus</i> L.
		118	<i>Gladiolus blandus</i> Ait.
		303	<i>Gladiolus carinatus</i> Ait.
		270	<i>Gladiolus gracilis</i> Jacq.
		269	<i>Gladiolus ?maculatus</i> Sweet
		322	<i>Lapeirousia aencens</i> Ker



- Fol.  
No.
- ORCHIDACEAE**
- 106 *Satyrion carneum* (Dryand) R.Br.  
136 *Disa cornuta* (L.) Swartz  
137 *Disperis capensis* (L.f.) Swartz
- ULMACEAE**
- 72 *Celtis africana* Burm. f.
- MORACEAE**
- 333 *Ficus cordata* Thunb.  
344 ?*Ficus cordata* Thunb.
- PROTEACEAE**
- 64 *Brabeium stellatifolium* L.  
37 *Serruria burmanni* R.Br.  
34 *Serruria glomerata* (L.) R.Br.  
32 *Mimetes hartogii* R.Br.  
23 *Mimetes hirta* (L.) Knight  
125 *Mimetes lyrigera* Knight  
249 *Diastella proteoides* (L.) Druce  
212 *Protea acaulis* Thunb.  
27 *Protea arborea* Houtt.  
28 *Protea arborea* Houtt.  
215 *Protea cynaroides* Thunb.  
216 *Protea cynaroides* Thunb.  
31 *Protea lepidocarpodendrum* (L.) L.  
30 *Protea macrocephala* Thunb.  
124 *Protea repens* (L.) L.  
126 *Protea scorzonifolia* (Salsb. ex Knight) Ryecroft  
25 *Protea scolymocephala* Reich.  
24 *Protea speciosa* L.  
127 *Leucospermum conocarpodendrum* (L.) Buck  
128 *Leucospermum hypophyllum* R.Br.  
211 *Leucadendron argenteum* (L.) R.Br.  
213 *Leucadendron coniferum* (L.) Druce  
218 *Leucadendron floridum* R.Br.  
243 *Leucadendron levisianum* (L.) Berg.  
217 *Leucadendron rubrum* Burm. f.  
26 *Leucadendron xanthocornum* (O. Ktze.) K.Schum.  
29 *Leucadendron xanthocornum* (O. Ktze.) K.Schum.
- PHYTOLACCACEAE (or AIZOACEAE)**
- 293 *Limeum capense* Thunb.
- AIZOACEAE**
- 195 ?*Pharnaecium* sp.  
19 *Aizoon sarmentosum* L.f.
- FICOIDACEAE (or AIZOACEAE sect. MESEMBRIANTHEMAE)**
- 196 *Carpobrotus edulis* (L.) N.E.Br.  
197 *Carpobrotus edulis* (L.) N.E.Br.  
339 *Conophytum* sp.  
193 *Glottiphyllum linguiforme* (L.) N.E. Br.
- Fol.  
No.
- 201 *Lampranthus emarginatus* (L.) N.E. Br. var. *emarginatus*  
202 *Mesembrianthemum crystallinum* L.  
194 *Ruschia filamentosa* (L.) L.Bol.  
326 *Sceletium* sp.
- RANUNCULACEAE**
- 47 *Anemone capensis* (L.) L.  
58 *Knowltonia capensis* (L.) Huth  
59 *Knowltonia capensis* (L.) Huth
- LAURACEAE**
- 66 *Cinnamomum camphora* Nees & Eberm. (Exotic)
- CRUCIFERAE**
- 329 *Heliophila* sp.
- CAPPARIDACEAE**
- 334 *Polanisia lutea* Sond.
- CRASSULACEAE**
- 9 *Cotyledon decussata* Sims. var.  
292 *Cotyledon decussata* Sims. var.  
132 *Cotyledon grandiflora* Burm. f.  
199 *Cotyledon orbiculata* L. var. *orbiculata*  
11 *Cotyledon paniculata* L.f.  
12 *Cotyledon paniculata* L.f.  
13 *Cotyledon ventricosa* Burm.f. var. *ventricosa*  
203 *Rochea coccinea* (L.) DC.  
10 *Andromischus caryophyllaceus* (Burm.f.) Less.
- SAXIFRAGACEAE**
- 104 *Montinia caryophyllacea* (Burm.f.) Less.  
105 *Montinia caryophyllacea* (Burm.f.) Less.  
311 *Montinia caryophyllacea* (Burm.f.) Less.
- CUNONIACEAE**
- 63 *Cunonia capensis* L.  
204 *Cunonia capensis* L.
- BRUNIACEAE**
- 60 *Staavia glutinosa* Dahl  
129 *Brunia nodiflora* L.  
20 *Berzelia abrotanoides* (L.) Brong  
214 *Berzelia lanuginosa* (L.) Brong
- ROSACEAE**
- 224 *Cliffortia ?ruscifolia* L.  
49 *Grielum grandiflorum* (L.) Druce
- LEGUMINOSAE**
- 343 *Acacia karroo* Hayne  
68 *Virgilia oroboides* (Berg.) Salter



- |   |   |
|---|---|
| Fol.<br>No.                                 | Fol.<br>No.                                       |
| 229 Podalyria biflora (Retz.) Lam.          | 144 Zygophyllum morgsana L.                       |
| 227 Podalyria calypttrata (Thunb.) Willd.   | 14 Zygophyllum sessilifolium L.                   |
| 226 Liparia sphaerica L.                    | 16 Zygophyllum spinosum L.                        |
| 228 Borbonia cordata L.                     |   |
| 236 ?Borbonia cordata L.                    | RUTACEAE  |
| 230 Borbonia lanceolata L.                  | 57 Agathosma ciliata (L.) Link.                   |
| 98 Rafnia humilis E. & Z.                   | 244 Adenandra umbellata Willd.                    |
| 235 Rafnia humilis E. & Z.                  | 56 Diosma hirsuta L.                              |
| 93 Rafnia triflora Thunb.                   |   |
| 97 Lotononis prostrata (L.) Benth.          | POLYGALACEAE                                      |
| 256 Lotononis prostrata (L.) Benth.         | 92 Muraltia heisteria (L.) DC                     |
| 299 Lebeckia cytisoides Thunb.              | 200 Muraltia serpyllodes DC                       |
| 301 Lebeckia cytisoides Thunb.              | 99 Nylandia spinosa Dam.                          |
| 231 Lebeckia ?plukenetiana E. Mey.          | 232 Nylandia spinosa Dam.                         |
| 233 Aspalathus ?acuminatus Lam.             | 314 Nylandia spinosa Dam.                         |
| 225 Aspalathus araneosus L.                 | 338 Nylandia spinosa Dam.                         |
| 162 Aspalathus commutatus (Vog.) R. Dahlgr. |   |
| 94 Aspalathus macranthus Harv.              | EUPHORBIACEAE                                     |
| 44 Aspalathus spinosus L.                   | 192 Euphorbia arceuthobioides Boiss               |
| 159 Aspalathus spinosus L.                  | 120 Euphorbia caput medusae L. var. caput medusae |
| 234 Aspalathus ?tridentatus L.              | 190 Euphorbia caput medusae L. var. caput medusae |
| 237 Aspalathus variegatus E. & Z.           | 183 Euphorbia clandestina Jacq.                   |
| 71 Indigofera cytisoides Thunb.             | 308 Euphorbia hamata Sweet                        |
| 62 Indigofera filiformis Thunb.             | 310 Euphorbia loricata Lam.                       |
| 342 Indigofera psoraloides L.               | 337 Euphorbia mauritanica L.                      |
| 55 Tephrosia capensis Pers.                 | 191 Euphorbia puginiformis Boiss.                 |
| 95 Lessertia miniata Salter                 | 302 Euphorbia stellaespinia Haw.                  |
| 96 Lessertia sp.                            | 188 Euphorbia tridentata Lam.                     |
| 273 Dolichos decumbens Thunb.               | 189 Euphorbia tuberosa L.                         |
| 152 Dolichos gibbosus Thunb.                |   |
|   | ANACARDIACEAE                                     |
| GERANIACEAE                                 | 315 Ozoroa argentea (Thunb.) Fernandez            |
| 348 Sarcaulon sp.                           | 61 Rhus augustifolia L.                           |
| 22 Pelargonium betulinum (L.) Ait.          | 254 Rhus lucida L.                                |
| 296 Pelargonium bifolium (Burm.f.) Willd.   |   |
| 295 Pelargonium echinatum Curt.             | AQUIFOLIACEAE                                     |
| 21 Pelargonium ferulaceum Willd.            | 205 Ilex mitis (L.) Radlk.                        |
| 294 Pelargonium fulgidum Willd.             | 208 Ilex mitis (L.) Radlk.                        |
| 298 Pelargonium fulgidum Willd.             |   |
| 261 Pelargonium ?hirsutum (Burm.f.) Ait.    | CELASTRACEAE                                      |
| 262 Pelargonium longifolium Jacq.           | 141 ?Maytenus acuminata (L.f.) Loes.              |
| 263 Pelargonium myrrhifolium (L.) Ait.      | 209 Maytenus acuminata (L.f.) Loes.               |
| 297 Pelargonium trifidum (Burm.f.) Willd.   | 148 Putterlickia pyracantha (L.) Endl.            |
| 264 Pelargonium triste (L.) Ait.            | 140 Pterocelastrus tricuspidatus Sond.            |
|   | 74 Cassine capensis L.                            |
| OXALIDACEAE                                 |   |
| 257a Oxalis flava L. formae                 | SAPINDACEAE                                       |
| 258 Oxalis flava L. forma pectinata Sond.   | 327 Erythrophysa alata Hutch.                     |
| 259 Oxalis pes caprae L.                    |   |
| 138 Oxalis purpurea L.                      | BALSAMINACEAE                                     |
| 257b Oxalis versicolor L.                   | 279 ?Impatiens sp. (Exotic)                       |
| 260 Oxalis sp.                              |   |
| LINACEAE                                    | RHAMNACEAE  |
| 275 Linum africanum L.                      | 220 Noltea africana (L.) Reichb. f.               |
|   | 219 Phylica plumosa L.                            |
| ZYGOPHYLLACEAE                              |   |
| 149 Zygophyllum fulvum L.                   |   |

- |             |  |             |   |
|-------------|--|-------------|---|
| Fol.<br>No. |  | Fol.<br>No. |   |
|             | VITACEAE                               |             |   |
| 156         | Rhoicissus capensis (Burm.f.) Planch.  | 313         | Diospyros austro africana de Winter<br>var. austro africana |
|             | TILIACEAE                              | 131         | Diospyros glabra (L.) de Winter                             |
| 157         | Grewia occidentalis L.                 | 340         | Diospyros ?glabra (L.) de Winter                            |
|             | MALVACEAE                              | 223         | Diospyros whyteana (Hiern) F. White.                        |
| 52          | Hibiscus diversifolius Jacq.           |             | OLEACEAE  |
| 281         | Hibiscus sp. (Exotic)                  | 70          | Linociera foveolata (E. Mey.) Knobl.<br>subsp. foveolata    |
|             | STERCULIACEAE                          | 76          | Jasminum sp. (Exotic)                                       |
| 221         | Hermannia diffusa L.f.                 | 65          | Olea africana Mill.   |
| 222         | Hermannia hyssopifolia L.              | 210         | Olea africana Mill.   |
|             | PENAEACEAE                             | 69          | Olea capensis L. subsp. capensis                            |
| 80          | Penaea mucronata L.                    |             | GENTIANACEAE  |
|             | OLINIACEAE                             | 46          | Chironia linoidea L.  |
| 67          | Olinia cymosa (L.f.) Thunb.            |             | ASCLEPIADACEAE  |
|             | THYMELIACEAE                           | 155         | Microloma tenuifolium (L.) K.Schum.                         |
| 248         | Gnidia pinifolia L.                    | 306         | Xysmalobium undulatum R.Br.                                 |
| 252         | Gnidia sericea (L.) L.                 | 331         | Asclepias fruticosa L.                                      |
| 245         | Struthiola ciliata (L.) Lam.           | 154         | Cyanchum obtusifolium L.f.                                  |
| 246         | Struthiola ciliata (L.) Lam.           | 18          | Caralluma incarnata (L.f.) N.E.Br.<br>var. incarnata        |
| 101         | Cryptadenia grandiflora (L.f.) Meisn.  | 17          | Stapelia hirsuta L. var. hirsuta                            |
| 102         | Cryptadenia uniflora (L.) Meisn.       | 123         | Stapelia variegata L. var.                                  |
|             | UMBELLIFERAE                           | 317         | (Asclepiadaceae)  |
| 54          | Hermas capitata L.f.                   |             | BORAGINACEAE  |
| 121         | Arctopus echinatus L.                  | 100         | Lobostemon fruticosus (L.) Buek                             |
| 206         | Arctopus echinatus L.                  |             | LABIATAE  |
| 280         | Sium sp. (Exotic) ?ninsi L.            | 33          | Ballota africana (L.) Buek                                  |
| 282         | Sium sp. (Exotic) ?ninsi L.            | 277         | Stachys aethiopica L.                                       |
| 332         | Annesorrhiza sp.                       | 43          | Salvia africana caerulea L.                                 |
| 300         | Peucedanum sp.                         | 42          | Salvia africana lutea L.                                    |
|             | CORNACEAE                              |             | SOLANACEAE  |
| 75          | Curtisia dentata (Burm.f.) C. S. Smith | 145         | Lycium afrum L.   |
|             | ERICACEAE                              | 143         | Solanum guineense L.  |
| 79          | Erica baccans L.                       | 142         | Solanum ?guineense L.                                       |
| 165         | Erica bauera Andrews                   | 150         | Solanum quadrangulare Thunb.                                |
| 84          | Erica caffra L.                        | 151         | Solanum tomentosum L.                                       |
| 167         | Erica caffra L.                        | 39          | Datura metel L. (Exotic)                                    |
| 164         | Erica grandiflora L.f.                 |             | SCROPHULARIACEAE  |
| 81          | Erica halicacaba. L.                   | 312         | Nemesia bicornis Pers.                                      |
| 82          | Erica halicacaba. L.                   | 345         | Nemesia cheiranthus E. Mey                                  |
| 83          | Erica ?imbricata L.                    | 146         | Halleria lucida L.  |
| 166         | Erica mammosa L.                       | 147         | Halleria elliptica Thunb.                                   |
| 250         | Erica phyllaefolia Salisb.             | 335         | Manulea benthamiana Hiern                                   |
| 251         | Erica plukenetii L.                    | 247         | Manulea cheiranthus L.                                      |
| 85          | Erica urna viridis Bolus               | 133         | Hyobanche sanguinea L.                                      |
|             | SAPOTACEAE                             |             | MYOPORACEAE   |
| 163         | Sideroxylon inerme L.                  | 103         | Oftia africana (L.) Berg.                                   |
|             | EBENACEAE                              |             | RUBIACEAE   |
| 328         | Euclea natalensis A.DC.                | 45          | Oldenlandia capensis L.f.                                   |
| 158         | Euclea racemosa J. A. Murray           | 207         | Gardenia jasminoides Ellis (Exotic)                         |
|             |  | 274         | Canthium inerme (L.f.) S. Moore                             |

Fol. No.		Fol. No.	
	<b>CURCUBITACEAE</b>		
153	<i>Kedrostis nana</i> (Lam.) Cogn.	90	<i>Senecio elegans</i> L.
	<b>CAMPANULACEAE</b>	15	<i>Senecio</i> sp.
41	<i>Wahlenbergia exilis</i> A.DC.	240	<i>Euryops abrotanifolia</i> (L.) DC.
267	<i>Cyphia bulbosa</i> (L.) Berg.	241	<i>Euryops ?pectinatus</i> (L.) Cass.
347	<i>Cyphia digitata</i> Willd.	48	<i>Othonna bulbosa</i> L.
276	<i>Lobelia coronopifolia</i> L.	198	<i>Othonna dentata</i> L.
255	<i>Lobelia erinus</i> L.	336	<i>Othonna leptodactyla</i> Harv.
38	<i>Lobelia pinifolia</i> L.	309	<i>Gamolepis speciosa</i> Pillans
40	<i>Monopsis lutea</i> (L.) Urb.	265	<i>Dimorphotheca nudicaulis</i> (L.) DC.
	<b>COMPOSITAE</b>	86	<i>Osteospermum ilicifolium</i> L.
160	<i>Corymbium ?glabrum</i> L.	169	<i>Osteospermum spinosum</i> L. var. spinosum
346	<i>Pteronia</i> sp.	170	<i>Chrysanthemoides monilifera</i> (L.) T. Norl.
88	<i>Felicia amelloides</i> (L.) Voss	89	<i>Ursinia</i> sp.
122	<i>Helichrysum foetidum</i> (L.) Moench	238	<i>Haplocarpha calendula</i> (L.) Levyns
78	<i>Metalasia muricata</i> (L.) Don.	341	<i>Gorteria</i> sp.
253	<i>Relhania ericoides</i> (Berg.) Cass.	239	<i>Gazania ?pinnata</i> (Thunb.) Less.
168	<i>Osmitopsis asteriscoides</i> (L.) Cass.	91	<i>Cullumia biscula</i> (Thunb.) Less.
87	<i>Cineraria geifolia</i> L.	242	<i>Cullumia setosa</i> (L.) R.Br.
		50	<i>Gerbera asplenifolia</i> (Lam.) Spreng.
		51	<i>Gerbera crocea</i> (L.) O.Ktze.





## STUDIES IN CYPERACEAE IN SOUTHERN AFRICA: VI.

### A NEW COMBINATION IN *FUIRENA* WITH NOTES ON THE SPECIES

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#### ABSTRACT

A new combination, *Fuirena hirsuta* (Berg.) P. L. Forbes, is made. A description, citation of specimens, illustrations and notes on variability within this species are given.

***Fuirena hirsuta* (Berg.) P. L. Forbes, comb. nov.**

*Cyperus hirsutus* Berg., Descr. pl. Cap. B. Spei: 11 (1767); Roem. & Schult., Syst. 2: 225 (1817); Kunth, Enum. Pl. 2: 114 (1837).

*Fuirena hirta* Vahl, Enum. Pl. 2: 387 (1805); Spreng. in Linn., Syst. Veg. 16, 1: 236 (1825); Schrad., Anal. Fl. Cap.: 52 (1832); Nees, Linnaea 7: 510 (1832), Linnaea 9: 288 (1834) name only, and Linnaea 10: 142 (1835-36); Kunth, Enum. Pl. 2: 181 (1837); Boeck., Linnaea 37: 108 (1871-3); Clarke in Dur. & Schinz, Consp. Fl. Afr. 5: 647 (1894) name only, in Dyer, Fl. Cap. 7: 264 (1898) and Bull. Misc. Inf. Add. Ser. 8: 116 (1908) name only; Schonland, S.A. Cyp., Mem. Bot. Survey S. Afr. 3: 52, pl. 55 (1922); Dyer, Rec. Albany Mus. 3: 481 (1927) ecological note only; Muir, Vegetation of Riversdale area, Mem. Bot. Survey S. Afr. 13: 34 (1929) ecological note only. *F. cephalotes* Schrad., Goett. Gel. Anz. 3: 2071 (1821). *F. erioloma* Nees, Linnaea 9: 288 (1834) name only, and Linnaea 10: 142 (1835-6); Kunth, Enum. Pl. 2: 181 (1837). *F. glabra* Kunth, Enum. Pl. 2: 182 (1837); Boeck., Linnaea 37: 101 (1871-3); Clarke in Dur. & Schinz, Consp. Fl. Afr. 5: 646 (1894) name only, in Dyer, Fl. Cap. 7: 264 (1898), Bull. Misc. Inf. Add. Ser. 8: 116 (1908) name only, and Illus. Cyp. tab. 59, 11 (1909). *F. intermedia* Kunth, Enum. Pl. 2: 181 (1837); Boeck., Linnaea 37: 101 (1871-3). *F. hottentotta* (L.) Druce, Rep. Bot. Exch. Cl. Brit. Isles 1916: 623 (1917); Fourcade, Checklist fl. pl. of divs. George, Knysna, Humansdorp and Uniondale, Mem. Bot. Survey S. Afr. 20: 85 (1940) name only; Levyns in Adamson & Salter, Flora of the Cape Peninsula: 118 (1950); Martin & Noel, Flora of Albany and Bathurst, Rhodes Univ., Grahamstown: 15 (1960) ecological note only.

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Accepted for publication 1st March, 1968.

*Scirpus hottentottus* Linn., Mant. Pl.: 182 (1771); Rottb., Descr. & Icon. Pl. 1: 54, tab. 16 fig. 4 (1773); Linn., Syst. Veg. 14: 101 (1784); Thunberg, Prodr. Pl. Cap.: 18 (1794), Fl. Cap. 1: 370 (1807) and Fl. Cap. ed. Schult.: 98 (1823). *S. glaber* (Kunth) T. Koyama, Journ. Fac. Sci. Univ. Tokyo 7 (6): 287 (1958).

*Perennial*, erect, 10—109 cm in height, generally 40—60 cm: *rhizome* horizontal, tough, woody, 3—8 mm across; scale leaves deltate or shallowly triangular, brown, striate, glabrous or sometimes puberulous, often torn: *culms* contiguous or up to 2 cm apart on rhizome, 2—7 mm across at base, leafy, triangular to terete, glabrous throughout, or glabrous or sparsely hairy below, becoming hirsute distally: *sheaths* shorter than internodes, hirsute to glabrous: *ligule* a membranous collar, usually hirsute, sometimes puberulous or glabrous, mouth slightly oblique; *blade* up to 28 cm long, 9 mm wide, generally 10—15 × 0.4 cm, longer than internodes, reduced or absent at base of culm, firm, more or less erect, hirsute, or sparsely hirsute to sub-glabrous when hairs on midrib and margin, or margin only, apex acuminate, acute in reduced blades: *inflorescence* terminal, of 1—3 heads, second and third heads, if present, subsessile or with hirsute peduncle up to 2.5 cm long, rarely with 1—2 additional long-stemmed lateral heads from node below terminal inflorescence, heads 0.6—2 cm, generally 1.5 cm across, globose, congested, echinate owing to long awns of glumes; bracts usually 2—3, unequal, longer or shorter than inflorescence, hirsute, sometimes sparsely so, often at base only: *spikelets* up to 8 mm long, 4 mm wide, generally 6 × 3 mm excluding projecting awns, ovate to oblong, not ranked, spicular: *glumes* numerous, lowest two only sterile, upper of which short, bicarinate, nerves 2 or indistinct, apex obtuse, truncate or slightly bilobed, muticous; remaining glumes about 5 mm long including awn, puberulous abaxially with numerous, sparse, or without long stiff hairs in distal half and on awn, body oblong, oblong-obovate, or oblong-elliptic, length  $1\frac{1}{2}$ —3 times width, keel rounded, excurrent into awn 1.5—2 mm long, subterminal, straight or recurved: *bristles* 3, rarely absent, opposite stamens, length usually from slightly shorter than scale claw to about half total scale length, sometimes up to  $2\frac{1}{2}$  times scale length, rigid, or soft and delicate, hairy, hairs mainly antrorse: *scales* 3, alternate with bristles, forming an inner whorl more or less equal to ovary and beak in length, unguiculate, aristate; claw woolly when mature, hairs absent in young flowers; blade oblong, square, elliptic, broadly elliptic or oblong-obovate in mature flowers, narrowly obovate when young, nerves 3, usually dark brown prominent, occasionally pale brown or opaque white, blade base truncate, obtuse or acute, lateral margins usually ciliate, rarely smooth or with sparse hairs, apex acute or obtuse, swollen, puberulous; awn antrorsely and extrorsely hairy: *stamens* 3, anther crest small, obtuse or acute, sometimes elongate then smooth or antrorsely scabrid: *achene*



FIG. 1: *Fuirena hirsuta* (Berg.) P. L. Forbes, type specimen in the Bergius Botanic Garden Herbarium, Stockholm.

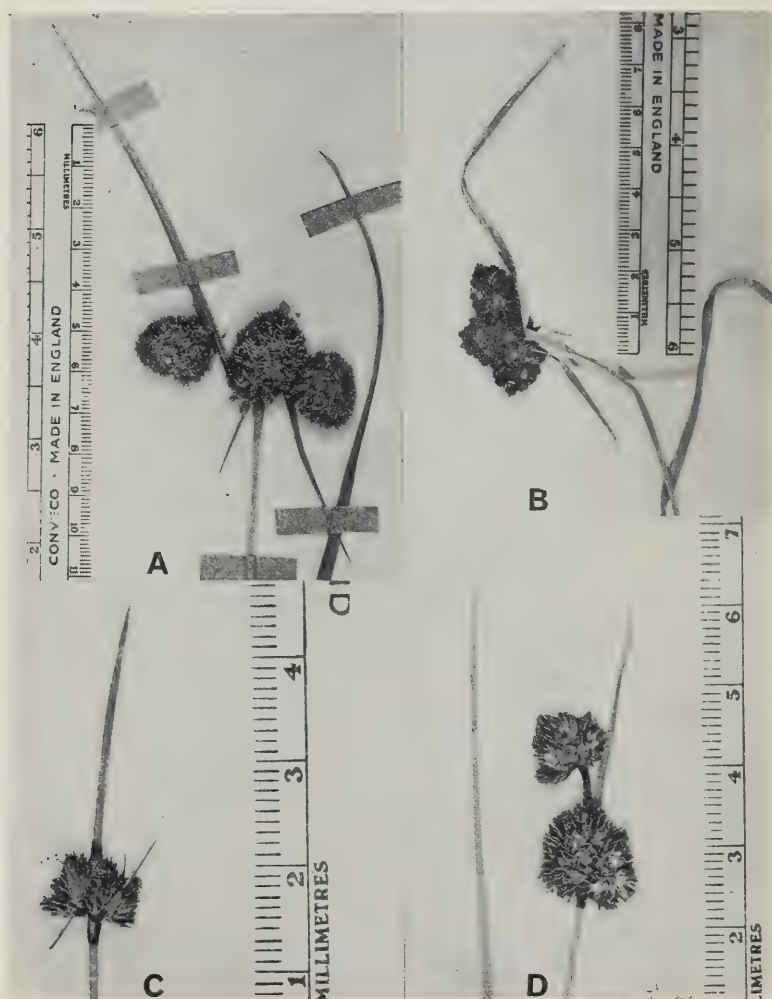


FIG. 2: *F. hirsuta*, variation in inflorescence, apical heads only shown: A—one sessile, two pedunculate (Parker 3624); B—three subsessile (Hilliard 2564); C—one sessile (Gordon-Gray 4760); D—one sessile, one pedunculate (J. L. Gordon-Gray 1102).

about 1.3 mm long including beak and stalk, broadly obovate, triquetrous, dark yellow, base acute, smooth or papillate, merging into slender stalk about 0.3 mm long; beak elongate, about 0.3 mm long, cylindrical, papillate, papillae elongate numerous, sometimes few and short, rarely absent: *outermost cells to pericarp* over broad faces of achene, transversely elongate with dovetailing end walls, arranged in fairly regular longitudinal rows, anticlinal walls rippled; longitudinally elongate at angles of achene, square over beak, square to longitudinally elongate over stalk.

Type: Deposited in the Bergius Botanic Garden Herbarium, Stockholm. The specimen, bearing the inscription "Cyperus mihi hirsutus" in Bergius' handwriting, consists of a portion of rhizome bearing three culms; the longest is about 30 cm and has an inflorescence of two terminal heads. The glumes are densely hirsute, and the flowers very young. The locality is given as "e Cap. b. sp." It was sent to Bergius by Michael Grubb, a former director of the Swedish East India Company, who visited the Cape in 1764. Possibly Grubb did not collect the material himself; he may have received it from J. A. Auge.

TRANSVAAL. Barberton distr: Louw's Creek, Wager s.n. (PRE).

SWAZILAND. Pigg's Peak distr: Komati R., Connolly s.n. (NU).



FIG. 3: *F. hirsuta*, variation in inflorescence, apical and lateral heads included: A—three stems showing (left) single apical head, (centre) single apical and one lateral head, (right) single apical and two lateral heads (Duthie 149); B—(centre) one sessile and one pedunculate apical head with one lateral head added (Pearson 5228).



MOZAMBIQUE. Sul do Save: Namaacha, *Myre & de Carvalho* 142 (NU, SRGH); *Balsinhas* 505 (PRE).

NATAL. Ngotshe distr: Ngotshe bank of Nkuzana R. on Nongoma-Magudu rd., *Gordon-Gray* 4760 (NU); Hlabisa distr: Hluhluwe Game Reserve, *Ward* 2107 (NU, NPGF); Lower Umfolozi distr: Ntambanana, *Salberg per Curzon* 15 (PRE); Mtunzini distr: Port Durnford, *Ward* 3476 (NPGF); do., *Venter* 1842 (ZU); Ngoye mt. Ubisana valley, *Venter* 1589 (ZU); Camperdown distr: Shongweni Dam, *Morris* 826 (NU); Durban distr: Isipingo Beach, *Ward* 753 (NU); Umzinto distr: near Scottburgh, *Gordon-Gray* 6134 (NU); Port Shepstone distr: in bed of Umzimkulwana R., *Oribi Gorge, Hilliard* 2564 (NU).

CAPE PROVINCE. Umzimkulu distr: Bisi, *Medley Wood* 3144 (NH); Bizana distr: 7 miles SSW of Bizana, *Acocks* 13407 (PRE); Elliotdale distr: Gwebe forest, The Haven, *J. L. Gordon-Gray* 270; 1102 (NU); Kentani distr: marshes, Kentani, *Pegler* 341 (BOL); Komgha distr: near Kei Mouth, *Flanagan* 1005 (PRE, GRA, BOL, SAM); Cathcart distr: Fort Cunynghame, *Sim* 2712 (PRE); East London distr: "Overton", 11 miles W of East London, *Hilner* 186 (GRA); Bonza Bay, *Acocks* 9556 (PRE); East London, *Ratray* 811 (GRA); Albany distr: Howieson's Poort, *Britten* 976 (GRA, PRE); hill near Grey Reservoir, Grahamstown, *Gane* 67 (GRA); Featherstone Kloof, Grahamstown, *Lubke* 68 (NH); Bathurst distr: Trappe's Valley, *Daly* 697 (GRA, BOL); Alexandria distr: Boesmansriviermond, *Edwards* 198 (NU); Port Elizabeth distr: Walmer, *Paterson* 2370 (GRA, BOL); Uitenhage distr: Uitenhage, *Paterson* 1925 (GRA); Swartkop R., *Zeyher* 4369b; 185; 168 (BOL); 361 (SAM); Hankey distr: Otterford Forest Reserve, *Rodin* 1153 (PRE, BOL); Humansdorp distr: 9.3 miles W by N of Kareedouw, *Acocks* 20032 (PRE); Assegaaibos Sta. on slopes towards Kromme R., *Schonland* 3061 (GRA); Humansdorp, *Rogers* 2912 (GRA, SAM); flats, Oudebosch, *Fourcade* 958 (GRA); Kouga R. on road from Zuur Anys, *Fourcade* 3104 (GRA); Uniondale distr: Uniondale, *Esterhuysen* 16419 (BOL); Knysna distr: "Vlugt", *Bolus* 2500 (BOL); Portland, *Duthie* 916 (GRA); Buffalo Bay, *J. Phillips* 24 (GRA); George distr: Swart R. gorge, *Acocks* 21239 (PRE); George, *Rogers* s.n. (PRE); Riversdale distr: Riversdale at Waterval, *Muir* s.n. (GRA); near Langeberg, *Muir* 2871 (PRE, GRA); Laingsberg distr: Seven Weeks Poort, *Thorne* s.n. (SAM 50151); Swellendam distr: National Bontebok Park, *Liebenberg* 6681 (PRE); Montagu distr: Keurkloof near Montagu, *Lewis* and *Esterhuysen* s.n. (BOL 27945); Robertson distr: *McGregor, Esterhuysen* 4903 (BOL); Ceres distr: Visgat, between Schurftberg and Great Winterhoek Mountains., *Stokoe* s.n. (SAM 66588); Worcester distr: Matroosberg, *E. P. Phillips* 2111 (SAM); Hex R. valley, *Tyson* 618 (GRA); s.n. (SAM 12642); Worcester, *Ecklon* and *Zeyher* s.n. (GRA); do., *van Breda* 370 (PRE); Caledon distr: near Palmiet R., *Bolus* 4227 (BOL); Hagelburg Pass, *Compton* 23686 (NBG); Hermanus distr: Hermanus, *Rogers* s.n. (PRE);

Tulbagh distr: in hills near Saron, *Schlechter* 600 (PRE, GRA); Wellington distr: Witte R. valley, Wellington, *Thorne* s.n. (SAM 46506); Paarl distr: du Toit's Pass, *Werdemann* and *Oberdieck* 738 (PRE); French Hoek, *E. P. Phillips* 1371 (SAM); Stellenbosch distr: Stellenbosch, *Duthie* 149 (BOL); Kuils R., *Zeyher* 4369a (BOL); Somerset West distr: Somerset West, *Parker* 3624 (PRE, NBG); Sir Lowry's Pass, *Maguire* 1065 (NU, NBG); Cape Town distr: Camps Bay, *Marloth* s.n. (PRE); Devil's Mt., *Ecklon* 34; 881; 882 (PRE); Wynberg distr: Cape Flats near Princess Vlei, *MacOwan* 3136, Herb. Afr. Cent. 18 1796 (SAM); Princess Vlei, *Forbes* 354, 366 (NU); roadside beyond Camp Ground, *Wolley Dod* 2203 (BOL); Kirstenbosch, *Wolley Dod* 2362 (BOL); Doornhoogte on the Cape Flats, *Zeyher* s.n. (PRE); Cape Flats at Hout Bay (*sic*), *Zeyher* 24 (SAM); Simonstown distr: Schuster's Bay, *Kies* 161 (NBG); Malmesbury distr: Mamre hills, *Wasserfall* 962 (PRE); Piketberg distr: farm "Waboom", slopes of Zebrakop, *Taylor* 5354 (PRE); eastern side Pickenier's Pass, *Pearson* 5228 (BOL); Clanwilliam distr: Waterfall, Citrusdal, *Maguire* 1064 (NBG).

The selection of specimens for citation and the herbarium abbreviations used, are as in previous papers in this series (Gordon-Gray 1966), with the addition of ZU for Zululand University College Herbarium, via Empangeni, Zululand.

*F. hirsuta* occurs in damp situations in the coastal region of Southern Africa. All plants studied were collected between Louw's Creek (eastern Transvaal) and Citrusdal (western Cape Province.) Clarke (1898) cites a Drège gathering from Clanwilliam which extends the range slightly further north-west than indicated here: this material has not been examined. Eyles (1916) and Brain (1934) mention a single specimen collected by Engler at the Victoria Falls. This material, which was housed in the Berlin Museum, has been destroyed. As it occurred so far out of the known range, it was possibly incorrectly identified.

It is unlikely that *F. hirsuta* occurs outside Southern Africa, although a plant from the Bosphorus, described as "*Juncus hirsutus*, foliis articulatis", by Buxbaum (1729) was cited under *Cyperus hirsutus* by Kunth (1837), and under *F. glabra* by Clarke (1894, 1898). Buxbaum's description and illustration are not clear enough to identify his plant as *Fuirena* nor has any type been located so far. Since no *Fuirena* has been recorded from the Bosphorus area (although *F. pubescens* Kunth does occur in Europe, the Lebanon and south-west Turkey), it seems likely that Kunth's and Clarke's citations were in error.

There is a distinct difference in appearance between plants from the south-western and north-eastern limits of the distributional range of *F. hirsuta*. Those from the western Cape Province have a dense mass of bristles on the abaxial surface of the glumes (Fig. 5A, H) so that the inflorescences are hirsute. In Natal and Zululand, glume bristles are few or absent, and when present

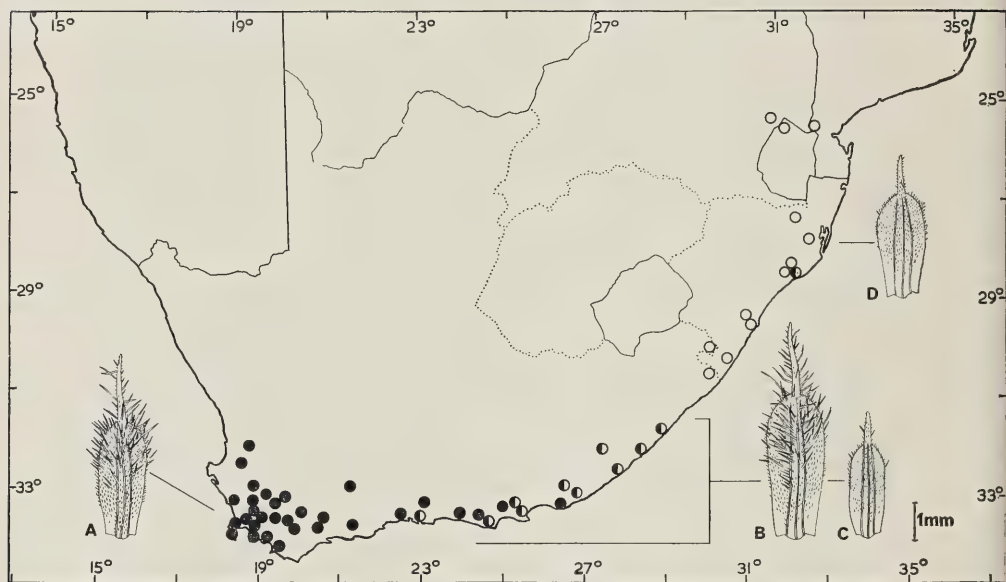


FIG. 4: *F. hirsuta*, distribution in Southern Africa: ●—plants with glumes hirsute; ◐—plants with glume bristles varying from many to few or absent, in different or in the same gatherings; ○—plants with glume bristles varying from few to absent in the same spikelet: A, B, D—glumes near spikelet base, abaxial surface; C—glume near apex of spikelet abaxial surface; A—Forbes 366; B—Gane 67; D—Morris 826; C—J. L. Gordon-Gray 270.

these are usually not as long as in typical Cape material (Fig. 5F, G). These two forms have previously been regarded as *F. hottentotta* (L.) Druce and *F. glabra* Kunth, respectively. But in the eastern Cape and Transkei there is considerable variation in the density of glume bristles; here the south-west and north-east types grade into each other, and there is no clear discontinuity between them. In this region, plants occur with numerous bristles as in the western Cape (Gane 67), or the glumes may be less hairy as in Natal and further north (Lubke 68). There are also instances where whole inflorescences may be hirsute, or less hairy, within a single gathering (Hilner 186, Britten 1976), and intermediates in which bristles on the glumes vary from quite numerous to absent within a single spikelet. Generally, in such intermediates, decrease in number of bristles per glume takes place from spikelet base to apex (Fig. 5C, D, E).

Variability is most evident in the area between Uitenhage and Bashee River

mouth, but it may occur both further north and south. *Ward* 3476 and *Venter* 1842 (Port Durnford, Zululand) have numerous bristles on the glumes, while *Fourcade* 3104 (Humansdorp) and *J. Phillips* 24 (Knysna district) have glumes with few bristles.

There is some degree of correlation between glume and culm indumentum. Generally, when bristles of the glumes are few or absent, culms are glabrous, while plants with densely hirsute glumes have a hirsute area at the culm apex immediately below the inflorescence, the remainder of the culm being more sparsely hirsute or glabrous. In plants showing variation in density of glume

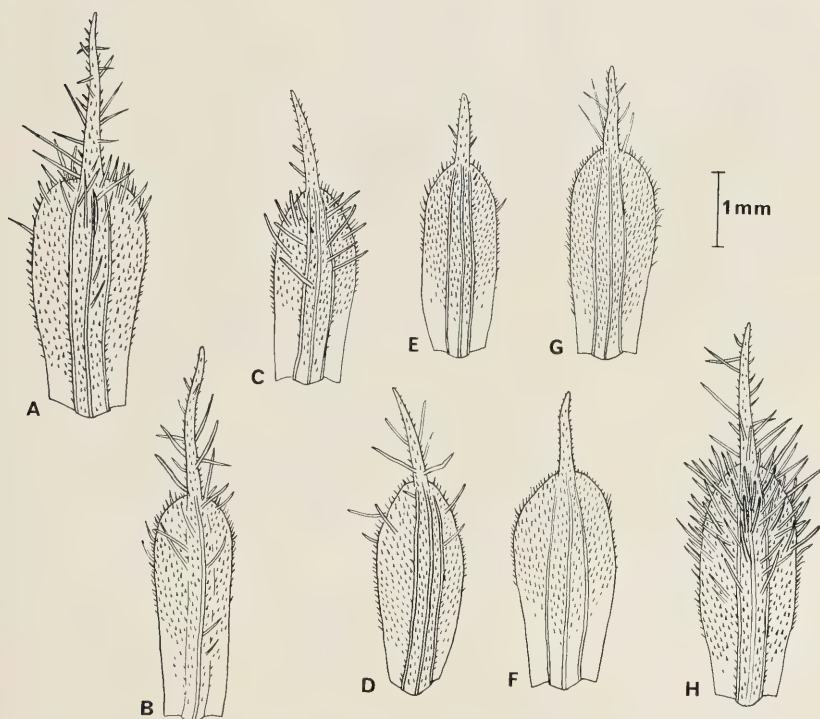


FIG. 5: *F. hirsuta*, abaxial surface of fertile glumes showing variation in indumentum. A, B, F-H—glumes near base of spikelet; A—Parker 3624 (Somerset West distr.); B—Britten 976 (Albany distr.); F—Morris 826 (Camperdown distr.); G—Balsinhas 505 (Sul do Save); H—Forbes 366 (Wynberg distr.); C, D, E—J. L. Gordon-Gray 270 (Elliotdale distr.); C—glume near base of spikelet; D—glume half way up spikelet; E—glume near apex of spikelet.



bristles, the culm apex may be glabrous or villous, or both conditions may occur in a single gathering (Hilner 186).

Leaf sheath and blade indumentum also show variability. Frequently, sheaths at the culm base are hirsute: higher up, hairs are absent from the lower portion of each sheath, the glabrous areas becoming progressively more extensive, until the uppermost sheaths have only a small distal patch of hairs, or are entirely glabrous. However, examples occur in which leaf sheaths are hirsute or glabrous throughout the plant. Leaf blades vary from hirsute to practically glabrous. Blade hairs are frequently marginal only; these may be very sparse so that large portions of the lamina are glabrous, but no plant with blades devoid of hairs was found.

Plants with all culm leaf sheaths hirsute have been found only in the south-western portion of the distributional range, and while plants with hirsute blades are similarly distributed, not every plant from this south-western region has these characteristics. Thus, while there is some correlation between density of glume and culm indumentum, the relationship does not hold for leaf sheath and leaf blade indumentum also. Nevertheless, there is a general tendency for the indumentum of abaxial glume surface, culm internode, leaf sheath and blade to be densest in the south-western, and sparsest in the north-eastern regions of the distributional range.

Kunth used terete as opposed to triangular culms as one character of *F. glabra*, but examination of a large number of specimens has shown this to be variable. Terete culms have ridges corresponding to the angles of the triangular stems, while the angles of the latter are often not sharp. Thus it is sometimes difficult to decide whether a culm is terete or triangular: there may also be variation in shape at different levels on the same culm, or two culms on the same rhizome may differ at the same level. Kunth gave Ecklon 882 as the type of *F. glabra*, but the sheet of this number examined (PRE) has a triangular stem: possibly other sheets of the same number have more terete culms. There is a general tendency for plants from the northern end of the distributional range to have rather slender and wiry, more or less terete culms, while those of south-western plants are stouter and more clearly triangular.

Variation in the shape and size of bristles and scales in the mature flower is shown in Fig. 6. Bristle length forms a series from less than that of the scale claw, to about two and a half times the length of the scale. Flowers with very long bristles are comparatively rare: usually bristles are about half the length of the scale or shorter. There may be some variation in bristle length in a single flower (Fig. 6C, D), but the extremes in length were never found together, nor was there correlation between bristle length and the nature of the indumentum of glumes and vegetative organs. Bristles are occasionally slightly expanded near the base (Fig. 6B, D), and they vary in texture from stiff, and slightly



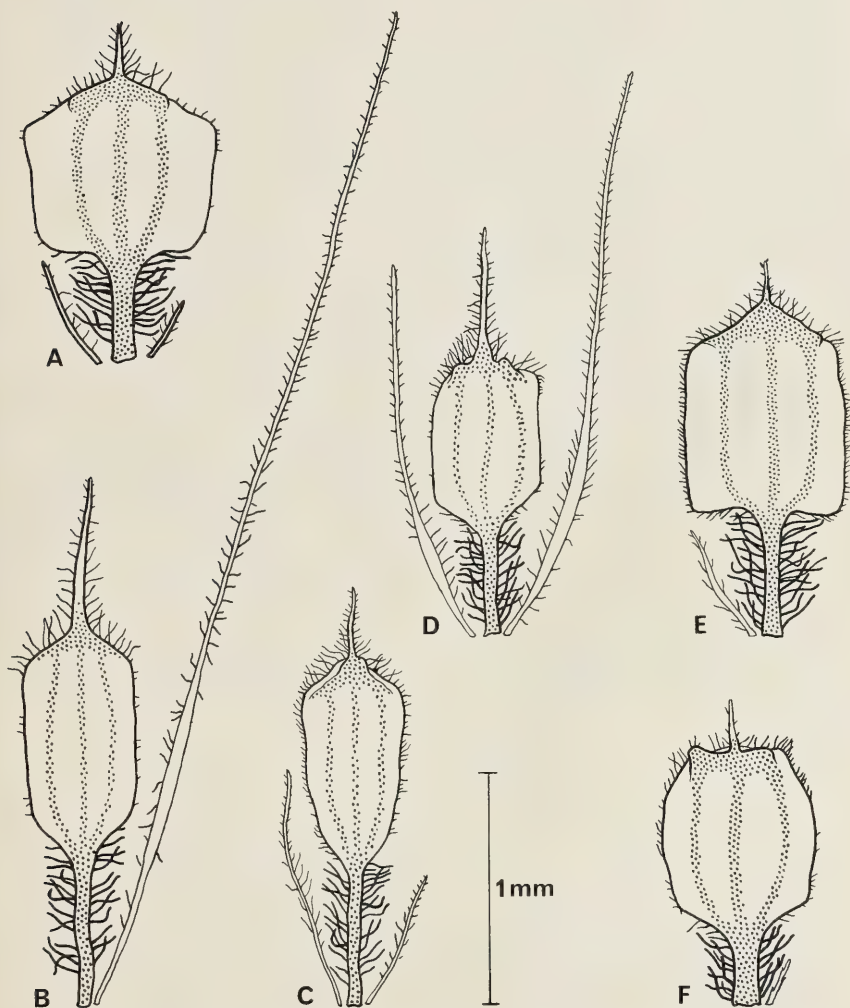


FIG. 6: *F. hirsuta*, A—F variation in size and shape of scales and bristles in mature flowers. A—Hilliard 2564; B—Ward 3476; C—Paterson 2370; D—Acocks 9556; E—Ecklon 882; F—van Breda 370.

spreading, to soft and delicate. Some authors (Schrader 1832, Nees 1835-6, Boeckeler 1871-3, Schonland 1922) have stated that bristles may be absent, but this is more infrequent than previously realised. Bristles are easily overlooked: in very young flowers, they adhere to the filaments, and in older material, if short and delicate, they are difficult to distinguish among, and to separate from, the hairs of the scale claws. In this investigation, bristles were found to be lacking only in *Werdemann* and *Oberdieck* 738. In *Phillips* 2111, they are exceedingly short. Consistent characteristics of the scales are the dense curling hairs on the claw, and the straight hairs on the blade apex and awn. The lateral margins of the blade are usually ciliate, but sometimes the hairs are sparse, and the margins almost smooth.

Changes occur in the appearance of bristles and scales with development. In very young flowers, bristles lack hairs, but these develop before the flowers are fully mature. The young scales are small, delicate, sessile and obovate, with a distinct but smooth spiculum. A little later, there is development of a more slender basal portion, the future claw, and the apiculum elongates to form the awn. With further lateral growth of the broad distal portion of the scale, the mature form is gradually assumed. Nerves can be seen at about the same time as a difference between blade and claw appears. Hairs on the blade apex and awn develop early, but hairs on the claw and on the lateral margins of the blade are not seen before the scale has more or less assumed the mature shape.

Because there is uncertainty about the true nature of bristles and scales (Blaser 1941, Holttum 1948, Kern 1962), the use of the term "perianth" in connection with these structures has been avoided.

The achene is characteristic of the species, being distinguished by a long slender stalk and long cylindrical beak (Fig. 7). The beak usually bears numerous elongate papillae, but occasionally the papillae are few and short, or rarely the beak is quite smooth. Papillae are usually present also on the ovary shoulders. Elongate or short round papillae may be present at the apex of the stalk, or this may be smooth. The characteristic beak develops when the ovary is still very young and slender, but the stalk is distinct only later, as the ovary becomes swollen. The rippled anticlinal walls of the pericarp epidermal cells (Fig. 7F) can usually be seen clearly only when the epidermis is detached from the pericarp.

In the middle of the nineteenth century, *F. hirsuta* was regarded as consisting of four species, namely *F. hirta* Vahl, *F. erioloma* Nees, *F. glabra* Kunth and *F. intermedia* Kunth. (*F. cephalotes* Schrad. was sunk into *F. hirta* by its author in 1832.) These species differed from each other in very minor respects. Inconsistencies in descriptions, and contradictions in citation of specimens show that they were not good species, and that there was misunderstanding about

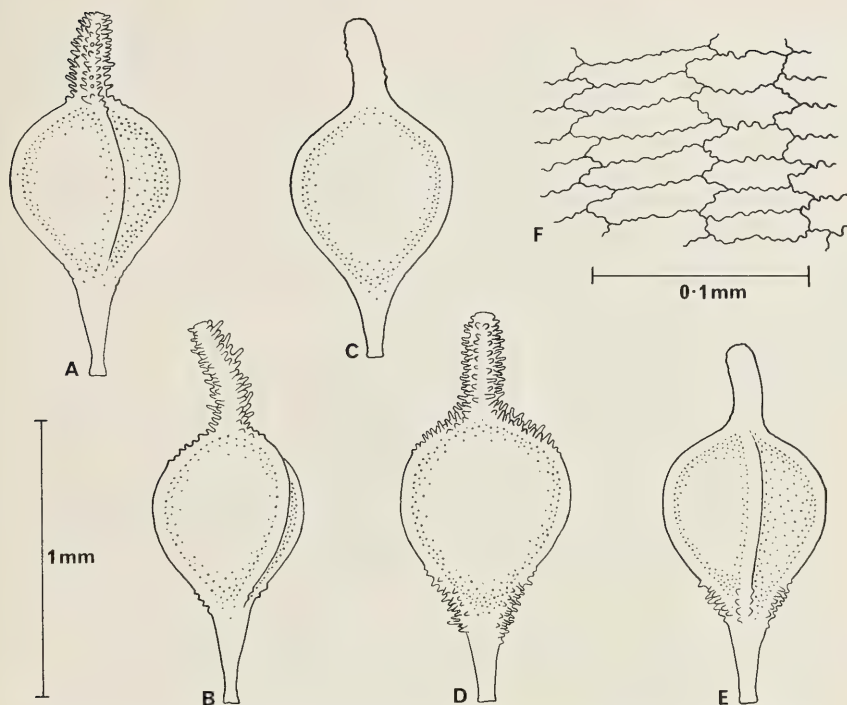


FIG. 7: *F. hirsuta*, A—E variation in the achene. A—Hilliard 2564; B—Liebenberg 6681; C—Werdermann & Oberdieck 738; D—Forbes 354; E—Tyson s.n. (SAM 12642). F—pericarp epidermal cells, Liebenberg 6681.

their exact limits. Boeckeler (1871–3) included *F. erioloma* in *F. hirta*, and in 1894, Clarke sunk both *F. erioloma* and *F. intermedia* into *F. hirta*, but retained *F. glabra* as distinct. The confusion was thereby partly simplified. In *Flora Capensis* (1898) Clarke described *F. glabra* as having “stems and leaves more than usually glabrous”, and cited specimens from the Transkei and East Griqualand, although Kunth had given the locality as “cap. b. spei.” *F. hirta* was described as “very hairy” and with “long excurrent midrib of the glumes long-pilose”; the citations are of specimens from the western Cape Province to Grahamstown. Thus Clarke indicated two taxa separated by degree of hairiness, and with different distributional ranges; he cited Ecklon 882 (Cape Town district) under *F. hirta* although Kunth had given this specimen as the type of *F. glabra*. Clarke’s interpretation of *F. glabra* is thus different from that of Kunth.

Schonland's (1922) treatment of the plants constituting *F. hirsuta* must be mentioned. He retained *F. hirta* as a species, but sank *F. glabra* together with *F. ecklonii* Nees, *F. gracilis* Kunth and *F. pubescens* Kunth into *F. coerulescens* Steud. This is an unsatisfactory arrangement. His figure of *F. hirta* is also not entirely accurate. There are certain consistent features which connect *F. glabra* more closely with *F. hirta* than with the species linked by Schonland, namely the echinate congested heads of numerous spikelets, the woolly scale claws, the long slender achene stalks, the elongate cylindrical beak to the ovary, and the transversely elongate pericarp epidermal cells. None of these characteristics are shared by the species included with *F. glabra* as *F. coerulescens* by Schonland. *F. coerulescens* (sensu Steud.) occasionally has a congested globose inflorescence of numerous spikelets but always differs in the other characteristics mentioned. Although a great deal of variation exists within species of *Fuirena*, and as Schonland rightly mentions, caution must be shown in using the scales as a diagnostic criterion, *F. hirta* and *F. glabra* form a natural group which cannot be divided as this author has attempted.

Because of unifying characters, it is impossible to treat this group as anything other than a single species. Because of intergradation, and the fact that hirsute and less hirsute forms occur in the same locality, in the same gathering, and to some extent on the same plant, it is pointless to recognise infraspecific categories.

*F. hirsuta* is fairly easily distinguished from other species of *Fuirena* occurring in Southern Africa, although it may show some external similarity in inflorescence form and glume indumentum to *F. microlepis* Kunth. But in *F. microlepis* the achene does not have a long slender stalk, and the beak is shorter; pericarp epidermal cells are hexagonal or sometimes slightly transversely elongate; the scale claw is very short with few hairs or glabrous, and the scale blade is obcordate with strongly incurved margins.

Koyama (1958) does not regard *Fuirena* and *Scirpus* as separate genera, but maintains that the scales in *Fuirena* represent an evolutionary line within *Scirpus* in which the linear bristles of *Scirpus* have become expanded. He has transferred five, apparently random, species of *Fuirena* to *Scirpus*. Among these is *F. glabra*, but he appears to be unaware of the relationship between *F. glabra* and *F. hottentotta*, as he does not mention the latter. At the present time the evidence for uniting the genera seems insufficient. A thorough investigation on a world basis is necessary; this should be tackled from different aspects such as anatomy, including nature and distribution of silica bodies, and chromosome number. For this reason, the species of *Fuirena* in Southern Africa are, for the present, being retained as a distinct genus. Should the transfer to *Scirpus* be made later, the name, *F. hirsuta*, would revert to *Scirpus hottentottus* L., as the epithet "hirsutus" has already been used in *Scirpus*.

## ACKNOWLEDGEMENTS

Sincere thanks are due to Dr. J. Tengnér, Stockholm, for a photograph and fragment of the type specimen, to Prof. P. H. Davis, Edinburgh, for information about the occurrence of *Fuirena* in Europe and south-west Asia, and to the herbaria mentioned for the loan of material. This work was carried out in the Botany Department, University of Natal, Pietermaritzburg, and I am grateful to Prof. A. W. Bayer and Prof. C. H. Bornman for making facilities available. Finally, I wish to pay tribute to Dr. K. D. Gordon-Gray for her unfailing advice, help and encouragement.

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## SECONDARY THICKENING IN GEOPHYTIC LILIACEAE

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### ABSTRACT

Secondary thickening is known to be present in seven geophytic species of the Liliaceae, but this is much less pronounced than in the well known arborescent Liliaceae.

In the arborescent species secondary thickening starts at a considerable distance from the apex of the stem, whereas it is initiated relatively near to the apex of the stems of the studied species.

The amount of secondary tissue is small and more secondary parenchyma than secondary vascular tissue is formed.

Secondary vascular bundles originate when some of the primary bundles branch, one branch being the secondary bundle, the other a continuation of the primary bundle.

The secondary bundle (branch) may be due to the activity of an intrafascicular cambium in the primary bundles.

In old parts of the rhizomes the cambium is sometimes transformed into storage tissue.

### INTRODUCTION

An idea which is prevalent among botanists is that secondary thickening in monocotyledons is limited to a few arborescent species of the Liliaceae. The related geophytic types have, however, not been fully investigated.

The only work which has been done on this problem in a related group in South Africa is that of Adamson<sup>1</sup> on the Iridaceae.

The following liliaceous species were examined during this study:

*Bulbine coetzeei* Oberm.

*Anthericum cooperi* Bak.

*Anthericum fasciculatum* Bak.

*Trachyandra saltii* (Bak.) Oberm.

*Chlorophytum comosum* (Thunb.) Jacques

*Chortolirion stenophyllum* (Bak.) Berger

*Urginea lydenburgensis* R. A. Dyer

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\*This work partially fulfilled the requirements for the M.Sc. degree of J. Coetzee at the University of Pretoria.

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Accepted for publication 6th November, 1968.

In the well-known representatives of the arborescent Liliaceae with secondary growth such as *Aloe*, *Dracaena*, *Cordyline* and *Yucca* (Anderson<sup>2</sup>, Röseler<sup>10</sup>), the secondary tissue forms an important part of the stem. This is, however, not the case in the species studied. In these species the secondary tissue is of lesser importance on account of the limited amount formed.

Holm<sup>8</sup> is of opinion that the secondary tissues in monocotyledons have two functions, firstly, to act as a "supporting apparatus" and secondly, to serve as tissue for the deposition of nutritive substances.

Support is, however, not necessary for stems or rhizomes of the plants studied, because of their compactness and subterranean habit.

As far as the storage tissue is concerned, starch grains were found in the older parts of the secondary tissue of *Trachyandra saltii*. Holm<sup>8</sup> reports the occurrence of starch grains in the secondary tissue of *Dioscorea sativa*, so that this may not be altogether an uncommon occurrence.

The paucity of secondary tissues in the species studied is perhaps due to the shortness of the stems. Plants with short stems transport water and nutritive substances over relatively short distances only. Cheadle<sup>6</sup> found that water is transported by the younger secondary xylem elements. In the species studied there is thus no "incentive" to form large amounts of secondary tissue.

Specimens of plants (usually in flower) were collected and fixed in formalin-aceto-alcohol. The stems or rhizomes were embedded in paraffin wax and serial sections made with a rotary microtome.

Sections were stained with Fast Green and Safranin. Most illustrations are, for the sake of clarity, combinations of drawings and photomicrographs.

#### MORPHOLOGY

Transverse sections of the rhizomes of the plants studied show that primary cell multiplication takes place just below the apex. This area is characterised by new cell walls laid down at random angles to the circumference of the rhizome.

Immediately below the apex procambial bundles are present (fig. 1). These bundles are embedded in the tissues of the primary meristem. In most species approximately six such procambial groups are formed. Large numbers of primary vascular bundles are present in the old parts of the rhizomes, but this small number of vascular initials are the only groups of vascular tissue which can unequivocally be referred to as being formed by the primary meristem.

Active primary cell multiplication is less evident in older tissues where the vascular bundles are differentiated into xylem and phloem.

In most of the named species a large number of calcium oxalate crystals are scattered throughout the parenchymatous tissues of the rhizome. These crystals are in the shape of raphides, or less often, druses. The crystals are abundant,

especially in the peripheral layers of the rhizome, but also appear in the rest of the tissues, even in the surrounding leaf bases. In *Chortolirion stenophyllum* approximately 4% of the parenchymatous cells contain crystals of calcium oxalate.

An annular ring which does not contain these crystals is present some distance below the apex, around the vascular system of the rhizome. This ring represents a band of meristematic cells which differentiate into a cambial band in older parts of the rhizome.

At no stage in the development of this cambium band are the meristematic initials present as a single layer of cells. As soon as the cambium band becomes visible, it is at least three cell layers in width (fig. 2).

An area in which no primary cell multiplication is evident, is present some distance below the apex of the rhizome. The cambial band becomes visible below this area. There is, therefore, a distinct cessation of primary growth before secondary growth is initiated. This is true in all the studied species.

The presence of this area in which no primary cell multiplication is evident, refutes the hypothesis of Carano (according to Cheadle<sup>6</sup>) that the primary and secondary meristematic regions are continuous.

The apices of secondary bundles are visible in the cambial band (fig. 3). These secondary bundles are continuously lengthened by the addition of procambial cells, originating in the cambial tissue.

When a series of transverse sections through the apical termination of a secondary bundle is studied, it is clear that more than one cambial cell takes part in the propagation of a secondary bundle at a specific height in the rhizome. This is in agreement with the findings of Lovén<sup>9</sup>, Adamson<sup>1</sup> and Esau<sup>7</sup>.

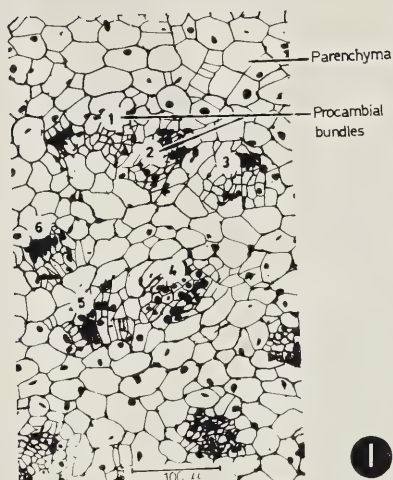
When a single section in which the apex of a young secondary bundle is situated, is studied, it is easy to misinterpret the propagation of such a young bundle and conclude that it is lengthened by the differentiation of the products of a single cambial cell, as Chamberlain<sup>5</sup> suggests.

In older parts of the rhizome the secondary bundles originate at the point where a primary bundle branches (fig. 4).

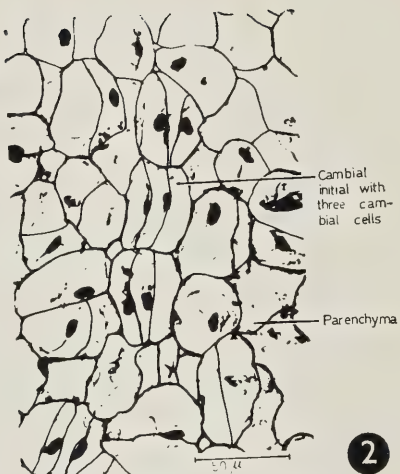
A primary bundle may branch several times within a relatively short distance, to give rise to successive secondary bundles, one being formed at each such branching.

It is not possible to state conclusively in which way a primary bundle gives rise to a secondary bundle. It is distinctly possible that a secondary bundle may develop from a primary bundle when the latter is not yet fully developed, by means of the intrafascicular cambium. This type of cambium was found in various primary vascular bundles of *Anthericum cooperi*, *A. fasciculatum*, *Chlorophytum comosum* and *Chortolirion stenophyllum*.

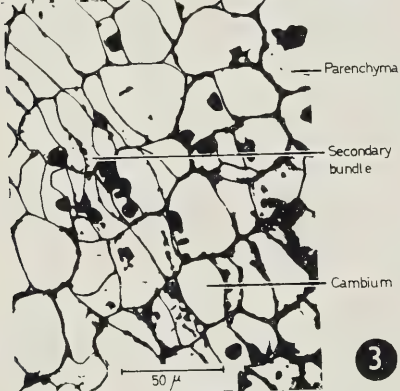
Especially in the case of (fig. 5) *A. fasciculatum* is the condition where a



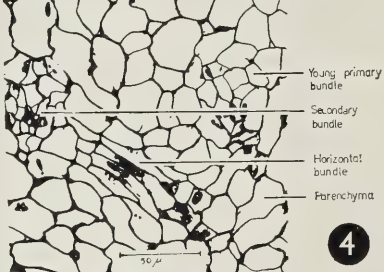
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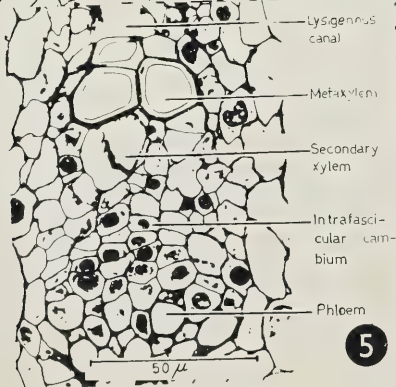
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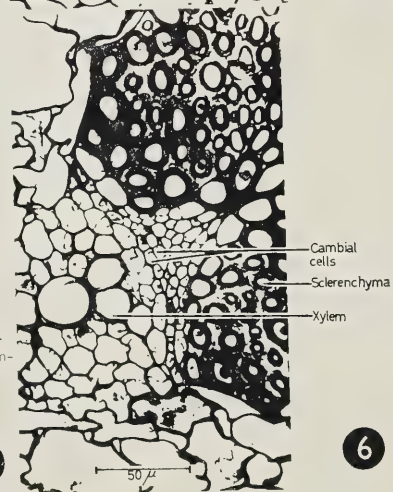
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secondary bundle may originate from the actively dividing intrafascicular cambium in a primary bundle strongly suggested.

Secondary bundles generally originate from primary bundles when the latter are fully or nearly fully differentiated. An intrafascicular cambium is present only in young primary vascular bundles (leaf traces), or in the procambial cell groups directly below the apex of the rhizome. In *A. fasciculatum* only is an intrafascicular cambium present in fully developed vascular bundles of old leaves (fig. 6). This seems to preclude an intrafascicular cambium from contributing to the formation of secondary bundles, but small numbers of such cambial cells may nevertheless be present in some of the primary bundles although not easily visible.

Arber<sup>3</sup> states that the presence of an intrafascicular cambium in monocotyledons is a widespread anatomical feature, a remark which is to a large extent substantiated in this study.

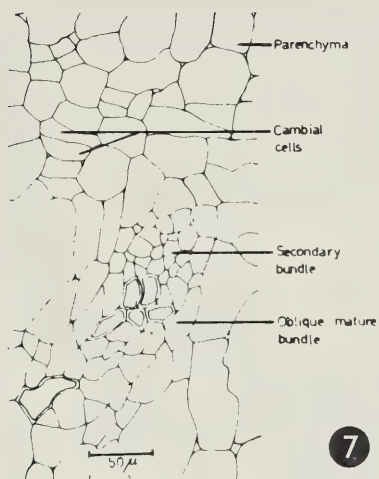
Arber<sup>4</sup> found lateral vascular bundles in the leaves of an unnamed species of *Anthericum*, originating in the intrafascicular cambium of primary vascular bundles. Much more, however, remains to become known of the formation or origin of these secondary vascular bundles.

Numerous connections exist between the primary and secondary vascular systems of the rhizomes. In serial sections through the rhizomes or stems of all the species studied, no single secondary vascular bundle which did not originate during a branching of a primary vascular bundle was found. In all cases these secondary bundles terminate apically in the cambial band some distance below the apex of the rhizome.

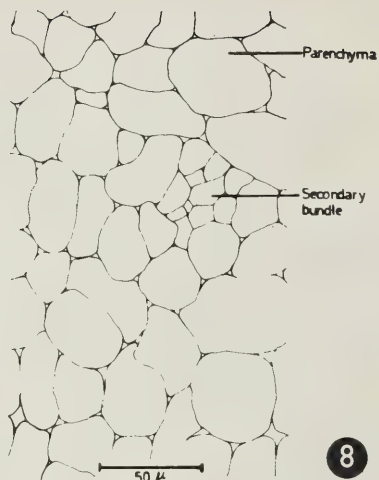
There seems to be a short distance only in which the cambial band is capable of forming secondary vascular bundles, because the apical terminations of such bundles are usually found in a rather short (less than 1.5 mm) vertical distance in the cambium. Below this "active" part of the cambium secondary bundles are also encountered, but no terminal points can be found, so that it can be inferred that no propagation of secondary vascular bundles takes place in this area.

In the "inactive" part of the cambium the secondary bundles may increase

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- FIG. 1. Transverse section of the rhizome of *Chlorophytum comosum*, showing six procambial groups of cells immediately below the apex.
- FIG. 2. Transverse section of the rhizome of *Trachyandra saltii*, showing the youngest cambial cells.
- FIG. 3. Transverse section of the rhizome of *Trachyandra saltii*, showing the apical termination of a secondary vascular bundle.
- FIG. 4. Transverse section of the rhizome of *Bulbine coetzei*, illustrating the branching of a primary vascular bundle.
- FIG. 5. Transverse section of the rhizome of *Anthericum fasciculatum*, showing the intrafascicular cambium in a primary vascular bundle.
- FIG. 6. Transverse section of the rhizome of *Anthericum fasciculatum*, showing intrafascicular cambial cells in an old primary vascular bundle.



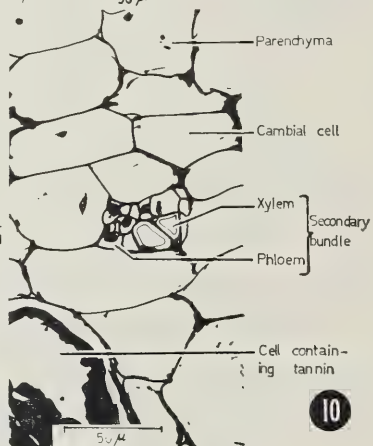
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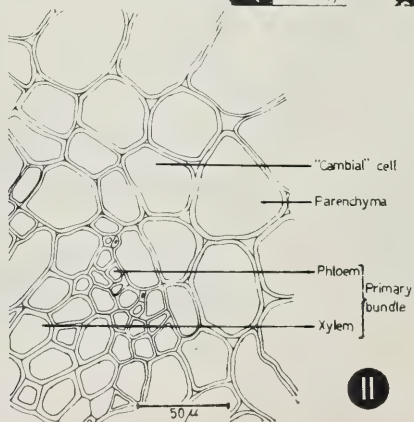
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slightly in diameter because of additional cambial cells which differentiate into secondary vascular tissue and are incorporated in the secondary bundles.

At the point where secondary bundles are at their oldest (just after emerging from a primary bundle) usually no differentiation into xylem and phloem is apparent (fig. 7). If differentiation has taken place, it is only to the extent of the formation of one or two xylem elements and a small number of sieve elements. No companion cells are formed.

Because of the undifferentiated state of the secondary bundles, even in a fully mature rhizome, these bundles cannot be very efficient transport pathways, either for water or organic substances.

It seems as if the cambial activity in these species is a rudimentary feature, reminiscent of the state found in the related arborescent Liliaceae, rather than an active mechanism for the formation of new transport facilities (secondary xylem and phloem) in the rhizome.

In *Chortolirion stenophyllum* a large number of secondary bundles may be found in a single transverse section of the rhizome, a short distance below the apex. At this distance from the apex the cambium is not present as a continuous band as yet in this species. It is only in the lower portions of the rhizome, where very few apical terminations of secondary bundles are present, that the cambium is visible as such a band.

The cambium in *C. stenophyllum* thus forms secondary vascular bundles when not fully differentiated (fig. 8) and, in the older state, secondary parenchyma only. The opposite is found in the other species, where the cambial band must be fully developed before secondary vascular bundles appear.

In all the species the amount of secondary vascular tissue formed is much less than the amount of secondary parenchyma produced.

Especially in *Trachyandra saltii* are the raphides of calcium oxalate present in all tissue of the rhizome, except in the cambial band itself. In the tissues between the cambial band and the epidermis, the raphides are oriented with their long axes approximately longitudinal to the long axis of the rhizome. In the tissues enclosed by the cambial band, the raphides are predominantly vertically oriented. No explanation for this observation can be tendered at present.

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- FIG. 7. Transverse section of the stem of *Urginea lydenburgensis*, showing the undifferentiated state of a secondary bundle at the point where it branches from a primary vascular bundle.
- FIG. 8. Young secondary vascular bundle appearing before cambial band is differentiated in a transverse section of the rhizome of *Chortolirion stenophyllum*.
- FIG. 9. Segmentation of the cambial band as seen in transverse section of the rhizome of *Trachyandra saltii*.
- FIG. 10. Transverse section of the stem of *Urginea lydenburgensis*, showing a fully differentiated secondary vascular bundle.
- FIG. 11. Transverse section of lower part of the rhizome of *Trachyandra saltii*, showing the thickened cell walls of the "cambium".

In most of the species there are indications of secondary vascular tissue produced by the cambium, taking part in the formation of adventitious roots. This can be seen in the younger parts of the rhizomes where adventitious roots are continuously being initiated. In these parts of the rhizome horizontal secondary vascular bundles appear next to the cambial band in the tissues between the cambium and the epidermis. These secondary bundles sometimes exhibit vascular cells in radial tiers, transversely across the length of the bundle. This is what is to be expected if these bundles are of secondary origin and differentiated laterally by a cambial layer. These vascular bundles appear prominently only where adventitious roots leave the rhizome, where the secondary bundles enter the adventitious root. In the process of entering the root the primary vascular bundles from the central parts of the rhizome break through the cambial band. This leaves semicircular segments of cambium around the vascular system of the rhizome, between the points where adventitious roots develop (fig. 9).

The secondary parenchyma does not seem to participate in the formation of adventitious roots, although it is difficult to determine exactly. This is due to the fact that much disruption of the regular orientation of cells is present at these positions. When the secondary parenchyma is not radially oriented, there is no way to distinguish it from the adjacent primary ground tissue.

The cambial band is recognisable as such only in the younger tissues of a rhizome. In the older parts it peters out, and is not visible a short distance above the oldest parts of the rhizome. This may be due to the limited formation of cambial tissues in the rhizome when very young, as well as to the disruption of regularly oriented tiers of cells because of the growth of surrounding tissues as the rhizome ages.

The maximum observed width of the cambial band (including the radially tiered secondary parenchyma) is approximately 12 cell layers. It is impossible to conclude in which specific cell layer the actual active meristematic cells are situated. It seems as if the idea of Schoute (according to Cheadle<sup>6</sup>) is correct. Schoute called the meristematic layer in monocotyledons an "Etagenmeristem". This meristem consists of cells which become meristematic, divide several times and then lose their meristematic character. The result of the activity of such an "etagenmeristem" would be the formation of a wide band of cells in which the true meristematic cells are distributed. Röseler<sup>10</sup> also found such cambial initials in a sheath or band of nominally meristematic cells. This is the only way in which the observed multilayered cambium could have developed. This view is strengthened by the fact that the apical terminations of young secondary bundles may be situated at different distances from the periphery of the cambial band.

In *Urginea lydenburgensis* a few secondary vascular bundles are present in the lowest parts of the cambial band. These secondary bundles differ from the



other secondary bundles encountered in that the xylem appears to be fully lignified and the phloem consists of cells with appreciably thickened walls (fig. 10). In this case the cambial cells are thin walled with large nuclei and still appear to be capable of cell division, although the cambial band is limited to a very few cell layers in width. The connection between these secondary bundles and the primary vascular system could not always be found, because of the extreme complexity of the vascular system in the oldest parts of the stem.

A rather similar condition is found in the lower parts of the rhizome of *Trachyandra saltii*, but in this case very few if any secondary bundles are present in the older parts of the rhizome. The cambial band, however, consists of cells with thickened cell walls, which should preclude cell divisions from taking place (fig. 11). Only in isolated parts of the "cambium" are the cells in radial tiers. In all other parts of the "cambium" the radial orientation of the cells is disrupted by the pressure of surrounding tissues. Starch grains are present in these cells, so that the cambium fulfills the functions of storage, rather than meristematic tissue.

In the younger parts of the cambial band of most species, primary leaf traces are present. These leaf traces are in some cases nearly completely undifferentiated and resemble secondary bundles closely. The only way in which they may be distinguished from secondary bundles is by following them from section to section to their upper and/or lower extremities. They appear to be present in the cambial band incidentally only, because other leaf traces, to all appearances exactly similar, are present both outside and inside the cambial band.

Peridermal tissue is present on the exposed surfaces of the rhizomes of most species. In *Anthericum cooperi* the parts of the rhizome which are protected by the old leaf bases are covered by a thickened and lignified epidermis, whilst those parts not protected by leaf bases are covered by a periderm of approximately three cell layers thickness.

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## THREE NEW RECORDS OF SOUTHERN HEMISPHERE BRYOPHYTA FOR SOUTH AFRICA

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### ABSTRACT

The Australian *Carrpos sphaerocarpos* (Carr) Prosk., (Marchantiales; Monocarpaceae) has been discovered in the Montagu division of the Cape Province; the family Monocarpaceae is validated. The mosses, *Pottia maritima* (R. Br. ter.) Broth., previously only known from New Zealand, and *Philonotis vagans* (Hook. f. & Wils.) Mitt., previously only known from southern Chile and South Georgia, are recorded for temperate South Africa.

Although a minority of the species of South African Bryophyta were known to have a distribution range extending to Australasia or temperate South America it was surprising to find three more in the first year of a collecting and research programme on the South African mosses. A fourth, a species of *Andreaea*, similar to the temperate South American *A. subnervis* Hook. f. & Wils. and to the New Zealand *A. nitida* Hook. f. & Wils., requires further comparative study.

The author wishes to thank Mr. J. H. Willis of the National Herbarium of Victoria, Australia, and Dr. H. Persson of the Riksmuseet, Stockholm, for providing material for comparison and for their taxonomic opinions.

**Carrpos sphaerocarpos** (D. J. Carr) J. Proskauer in Taxon 10: 155 (1961).

*Monocarpus sphaerocarpus* D. J. Carr in Austr. Journ. Bot. 4 (2): 176 (1956).

Cape Province, Montagu division, roadside 300 yards from Baths Hotel, in saline depression under *Suaeda fruticosa*. 6. x. 1968. *H. Tölken* 1586 (BOL, MEL).

This minute hepatic, with thalli less than 1·5 mm in diameter was previously only known from a few localities in the state of Victoria, Australia, where it also grows on saline soils. However, in Australian material seen, collected by Mr. Willis (MEL 28508), on saline mud amongst halophytic shrubs in north-western Victoria the plants are up to 4 mm in diameter.

The primary thallus is an undifferentiated cup-shaped structure with smooth-

walled rhizoids produced at the base. This supports a shortly stalked, aerated, almost globose involucre within which the few archegonia, and eventually, the single sporophyte develops. The spores in the South African plants appear to be identical in ornamentation with those of the Australian plants. However, this species appears to be dioecious and the male gametophyte has yet to be found.

Unfortunately Carr (1956) did not validate his proposed family Monocarpaceae, only remarking that "It may be placed in Müller's system (1954, p. 195) as Suborder AA, Monocarpineae; Family 4A, Monocarpaceae: 'Monocarpus'." As this does not constitute valid publication of the name of the family a description is published here.

MONOCARPACEAE Carr ex Schelpe fam. nov.

Plantae annuae terrestres minutae. Planta feminea usque ad 4 mm. lata. Planta mascula ignota. Thallus primarius femineus cupulatus; involucrem breviter pedicellatum subcarnosum subglobosum cavernosum. Archegonia 2-3. Sporangium unicum subglobosum breviter caulescente.

Type genus: *Carrpos* (J. D. Carr) Proskauer in Taxon 10: 155 (1961) (*Monocarpus* D. J. Carr. in Austr. Journ. Bot. 4 (2): 176 (1956)).

On the available evidence, the present author is disinclined to follow Carr (1956) in placing this family in the Marchantiales but prefers to discover the male gametophyte before deciding on its proper taxonomic position, which appears to be intermediate between the Sphaerocarpaceae and the Marchantiales.

***Pottia maritima*** (R. Brown ter.) Broth., Nat. Pflanzenf. 1 (3): 423 (1902).

*Dendia maritima* R. Brown ter. in Trans. New Zeal. Inst. 30: 411, t.41, fig. 3 (1898).

Cape Province, Montagu division, roadside 300 yards from Baths Hotel, in saline depression under *Suaeda fruticosa*. 6. x. 1968. H. Tölken 1586a (BOL, MEL).

This minute species of *Pottia* (subgen. *Schizophascum* (C. Muell.) Broth.) was previously regarded as endemic to New Zealand. The only other species of this subgenus known, is *P. disrumpens* (C. Muell.) Broth. from Victoria, Australia. As Sainsbury (1955) remarks, the capsule is unusual in that it is cleistocarpous and has a long beak, and opens by a break about the middle. The South African specimens were found intermingled with the plants of *Carrpos sphaerocarpos* mentioned above.

***Philonotis vagans*** (Hook. f. & Wils.) Mitt. in Journ. Linn. Soc. Bot. 4: 80 (1859).

*Bryum vagans* Hook. f. & Wils. in London Journ. Bot. 30: 546 (1844).

Cape Province, Worcester division, Krom Rivier Kloof, off Du Toits Kloof; in deep wet gully on wet rock face. 4. iii. 1956. *Esterhuysen* 25391 (BOL, S-PB), *Esterhuysen* 25392 (BOL).

This robust, pale shining green moss was previously only known from cold temperate South America. According to Persson (priv. comm.) it is also known from South Georgia. The South African material is virtually identical with some stems of *Santesson* 442 (BOL ex S-PB) from Rio Rubens, Terr. Magellanes, Chile. This species, referred to *Philonotis* sect. *Pseudo-Mniobryum* Broth., is recognisable by the minutely serrated bordered margin of the leaf which is differentiated at the leaf base into an alar-like group of shorter and broader cells outside the downward continued border of narrow cells.

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## ANNULAR CURVES OF THE OSMOTIC PRESSURE OF CERTAIN PLANTS ON THE CAPE FLATS

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In continuation of the investigation of Walter and van Staden (1) the osmotic pressure of the cell—sap of the following species, growing on the campus of the U.C.W.C., was determined, at convenient intervals, for a period of one year: *Othonna coronopifolia* L., *Leucospermum hypophyllum* R. Br., *Euclea racemosa* Murr., *Rhus mucronata* Thunb. and *Olea africana* Mill. As shown by Braun—Blanquet and Walter (2) the annular curve of the osmotic pressure of some typical representatives of the flora would be representative of the water conditions of the flora in general.

The campus is situated on the Cape Flats near Bellville. It is a flat, sandy stretch of land with sand dunes on the western side of the campus which have an East-West exposition. The dunes vary in height up to four metres above the immediate environment. The altitude is approximately the same as that of the Bellville railway station which is given as 70 m (230 ft.).

There are few indications as to the depth of the water-table. During the rainy season small waterpools are not uncommon, and trenches dug for constructional purposes are often flooded. This has led to the belief that the water-table is very shallow. Walter and van Staden (1) mention a depth of 5 m during the rainy season and 8 m during the dry season. A borehole drilled on the campus to a depth of 50 m yielded only a couple of hundred L/h. Thus it appears that the water-table is deeper than generally believed.

*O. coronopifolia*, a shrub usually less than 1 m high with semi succulent leaves, and *L. hypophyllum*, a trailing shrub with partially subterranean stems, grow on the flat sandy surface while *E. racemosa*, *R. mucronata* and *O. africana* grow approximately 150 m to the west on the sand dunes. Material of the latter three species was collected at the foot of a dune while leaves of *O. africana* were also collected on top of the dune.

**Materials and Method:**

At convenient intervals leaf samples, less than six months old, were double collected close to the growing tip; and, similarly, leaves of the previous growing season, the latter naturally being more than six months old. Material was always collected on clear sunny days at about 11 o'clock. The leaves were directly placed in glass vials with the tops well screwed down to prevent the loss of water by evaporation.

In the laboratory the closed vials were placed in a glass beaker with water and boiled for five minutes to kill the leaves. According to Walter (3) this method yields the most reliable results as it also stops enzymic action which influences the osmotic pressure of the cell-sap. The vials which were available for the present investigation were, to a certain extent, unsuited for the purpose as a complete sealing off could not always be effected. Vials giving off bubbles were immediately removed and the material was not used for the purpose of this investigation. The method was soon discarded and chloroform fumes were used to kill the plant material. The vials were then kept in a refrigerator overnight to prevent further enzymic action. As Walter (4) points out, these fumes are soluble in water and influence the depression of the freezing point of water by  $-0.102^{\circ}\text{C}$ . (4). The results were accordingly corrected.

The material was then placed in a pressure cylinder of stainless steel, with a perforated base and a tight-fitting piston. Pressure was slowly applied and steadily increased by means of a hand press, and the cell-sap collected in a vial in a closed space where evaporation was practically nil.

The depression of the freezing point was determined in a microcryoscope, by means of a Beckman thermometer and the osmotic pressure determined from the tables published by Walter (4).

Double collecting ensured a check on the results. On the whole there was a large measure of correspondence, but in a few cases there was an appreciable difference. However, the graph was in all cases drawn to a point between the two values if these did not coincide.

*Climatic data* were obtained from the weather station at the D. F. Malan Airport situated on the Cape Flats about two miles from the campus. The difference in climate is hardly appreciable.

The climatic graph published by Walter and van Staden (1) is typical for winter rainfall areas, except that the summer months are not completely rainless. With the exception of the few light showers registered during each month, there were often mornings with a light drizzle that cannot be measured by conventional means. Although summer showers are generally light, they may often be quite considerable as during November, when more than 250 mm were registered for one day. March was the driest month with a reasonably high temperature. During the winter months there was a fairly even distribution of the rainfall.

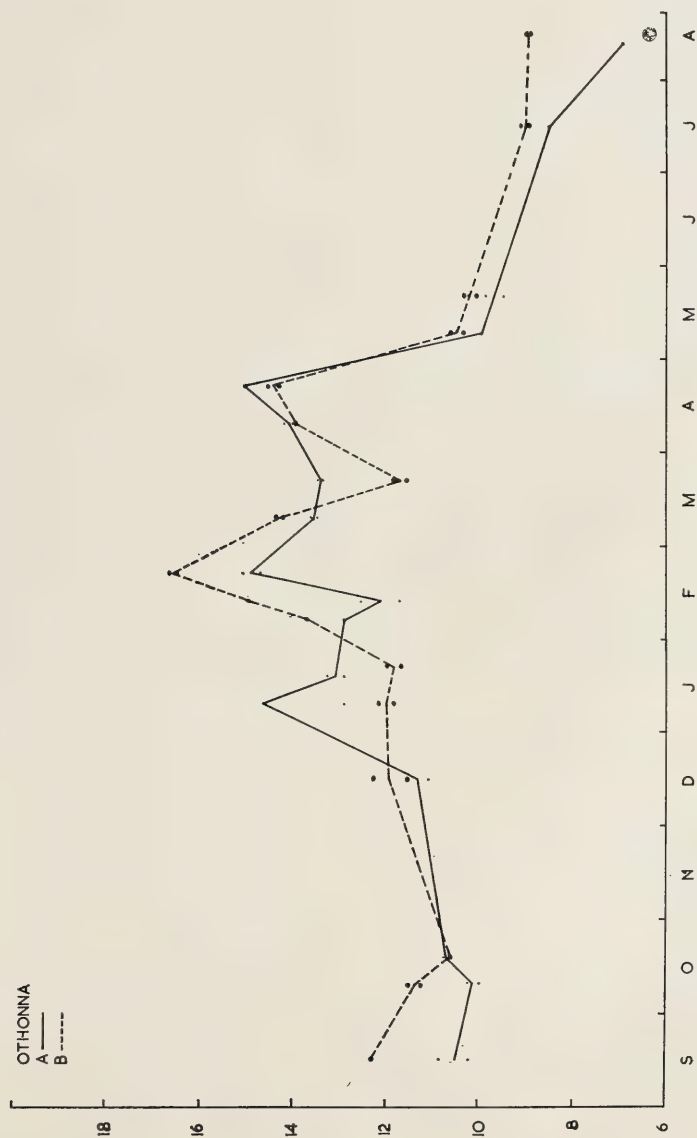
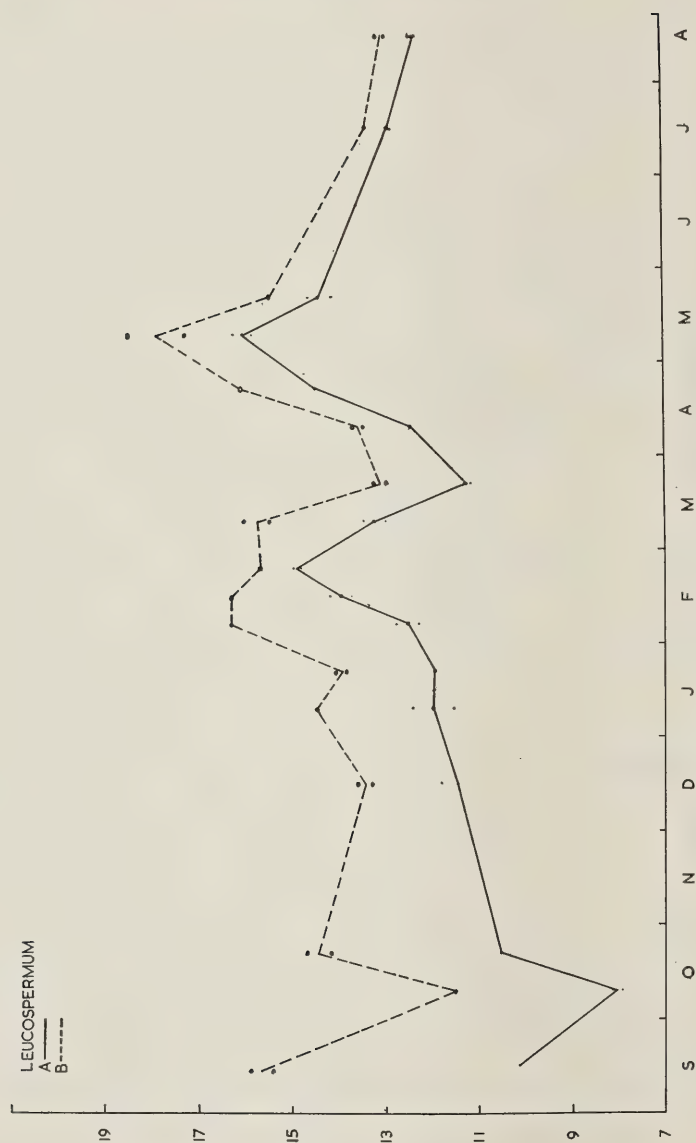


FIG. 1. Osmotic Pressures of *Othonna coronopifolia* L.

FIG. 2. Osmotic Pressures of *Leucospermum hypophyllum* R.Br.

Throughout the summer the temperature seldom rose above 30°C, the highest maximum being recorded on the 27th December, 1967, namely 35°C. Similarly, the temperature seldom dropped to zero. The lowest minimum was recorded on the 17th August, 1968, namely -0.2°C — a very mild climate therefore, with very little frost and few really hot days. During the summer months, however, the South-Easter which is a dry wind, blows almost daily. Transpiration can thus become excessive.

The graphs show the osmotic pressure along the ordinates and the months from September, 1967 to August, 1968 along the abscissae. The values for the double collections are indicated and the graph is drawn to the middle point between these two, even where one value is apparently wrong. The solid line A indicates the values obtained for the cell-sap of the young leaves and the broken line B for that of the older leaves. In the composite graph Fig. 7 only the values obtained for the cell-sap of the young leaves have been indicated. The rainfall graph shows the precipitation in mm. as measured at the D. F. Malan Airport.

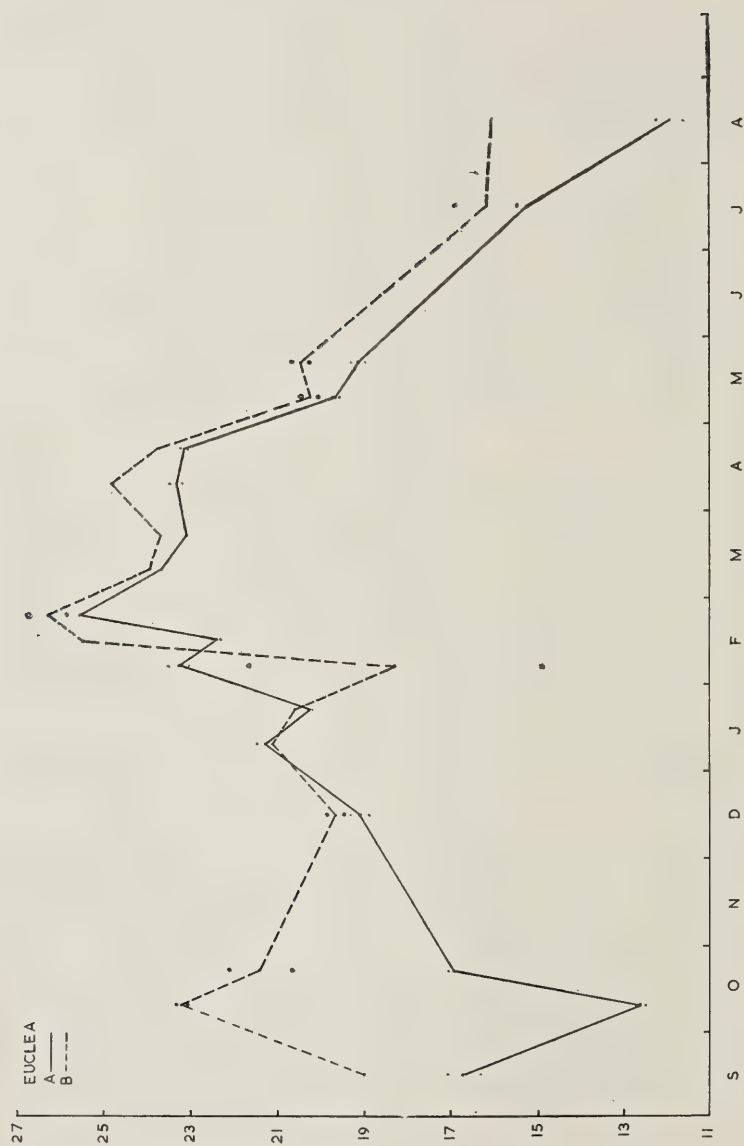
*Othonna coronopifolia* (Fig. 1): The two determinations for the osmotic pressure of each point largely coincide closely, the difference being less than one atmosphere, thus within the limits of the experimental error. The exception is the first determination for A during January. The difference of over three atmospheres indicates a very appreciable error. Its nature, however, is unknown. On the whole the graph indicates a low osmotic pressure during the rainy season and a rise during the dry summer months. The difference of approximately seven atmospheres between lowest and highest osmotic pressure is relatively small and indicates a hydro-stable condition. This is in accord with the general results concerning succulents (5).

Although the osmotic pressure of the older leaves is generally higher than that of the younger, the graph of the former did sometimes sink below that of the latter.

It should be pointed out that, with the advancing summer, the older leaves were gradually cast off until none remained. Thus, at the end of summer there was little age difference between the oldest and youngest leaves. The abnormal decline of the osmotic pressure of the older leaves during the latter part of the summer is thus understandable.

*Leucospermum hypophyllum* (Fig. 2): These plants grow approximately 50 m away from the former under more or less similar edaphic and climatic conditions. Again the graphs followed the climatic conditions within reasonable limits and rose from 8.5 atmospheres in September, 1967 to 17.9 atmospheres in May, 1968. In spite of a more xerophytic type of leaf these values do not differ much from those of the semi leaf succulent *O. coronopifolia*. The reaction to climatic



FIG. 3. Osmotic Pressures of *Euclea racemosa* Murr.

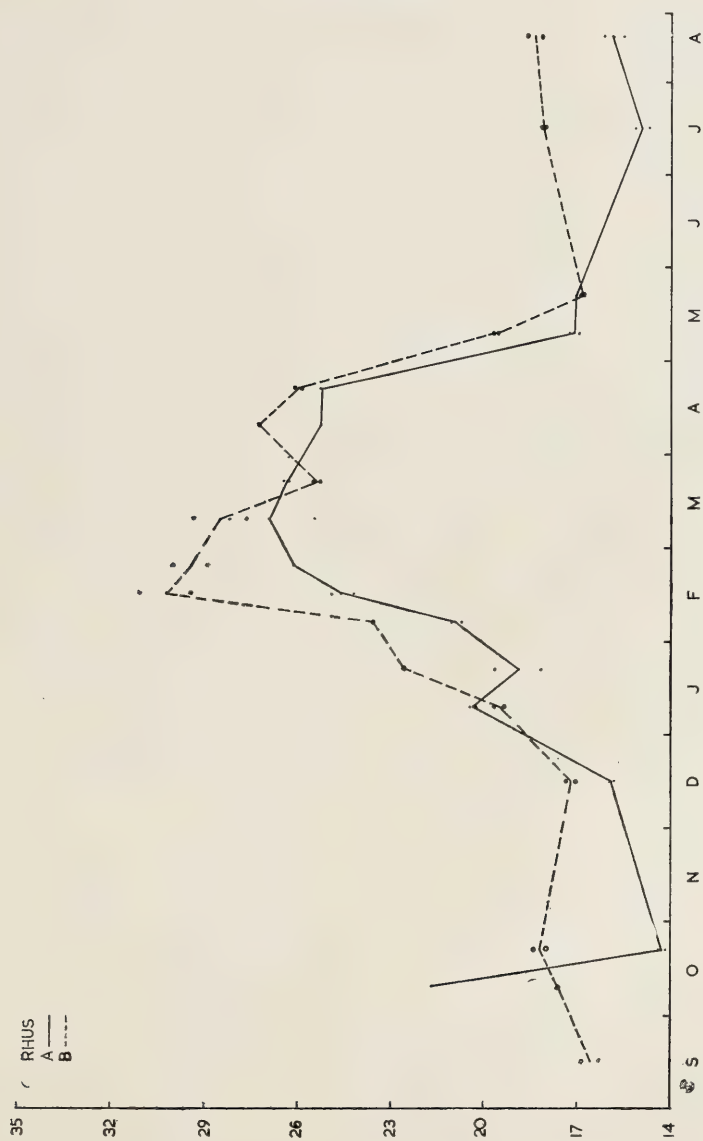


FIG. 4. Osmotic Pressures of *Rhus mucronata* Thunb.

conditions was, however, quite different. Both plants reached a maximum during February but *O. coronopifolia* reacted much faster to the small showers that fell during this month. It was only about a fortnight later that the osmotic pressure of *L. hypophyllum* also dropped sharply. This may be as a result of the deeper root system of the latter. The phenomenon repeats itself during the April–May period when a second maximum was reached, and even in the middle of August the osmotic pressure of *L. hypophyllum* was still considerably higher than during October of the previous year. The present graph corresponds well with that obtained by Walter and van Staden (1). It shows again that, in sandy soil, a plant with a strong root system utilizes the water which seeps down to a considerable depth and is little influenced by either small showers or sudden rises in temperature. Furthermore, the graph remains fairly flat, showing relatively small differences in the water condition of the plant during the different periods of the year.

*Euclea racemosa* (Fig. 3): On the whole the values obtained correspond well, with the exception of those obtained during October, 1967 and February, 1968, where there is apparently a very considerable experimental error. The amplitude is in this case much higher than in the former two, the osmotic pressure varying between almost 12 atmospheres to slightly over 26 atmospheres. The small showers from December, 1967 to February, 1968 had only a slight influence on the water relations of the plant. Only the continual showers from April, 1968 to August caused a sharp decline in the osmotic pressure.

*Rhus mucronata* (Fig. 4): Again the results correspond well, but there are a few cases where the variation is large. The graph shows the same general trend and a close correspondence with that of *E. racemosa*. The shrubs grow close together at the foot of a dune, but the leaves of the former are both smaller and more leathery than those of the latter. Yet the maximum osmotic pressure of the former is slightly below that of the latter. The maximum was reached in February, 1968. As in the former species, a decline appeared during March, the driest month of the period under observation.

*Olea africana* (Fig. 5): Leaves from specimens at two stands were collected and investigated, both in the vicinity of the former two species, viz. at the foot and at the top of the dune. The most striking characteristic of these two graphs is the exceptionally high osmotic pressure reached during March, 1968, when the other species showed a slight decline and a very sharp drop in osmotic pressure during the latter half of April to May, 1968. In both cases the difference between the osmotic pressure of the older and younger leaves is relatively slight during the periods of maximal value, the osmotic pressure of the older leaves being often slightly lower than that of the younger leaves. At this stage, as can be expected, active growth had stopped completely and the younger leaves were almost as hard and leathery as the older ones.

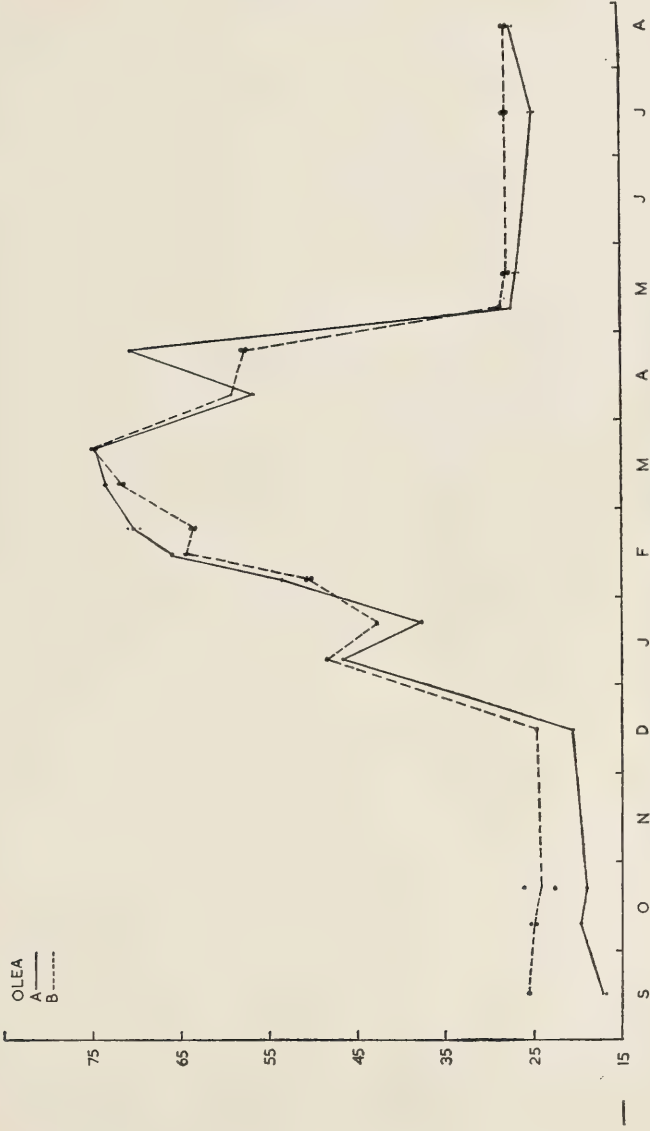
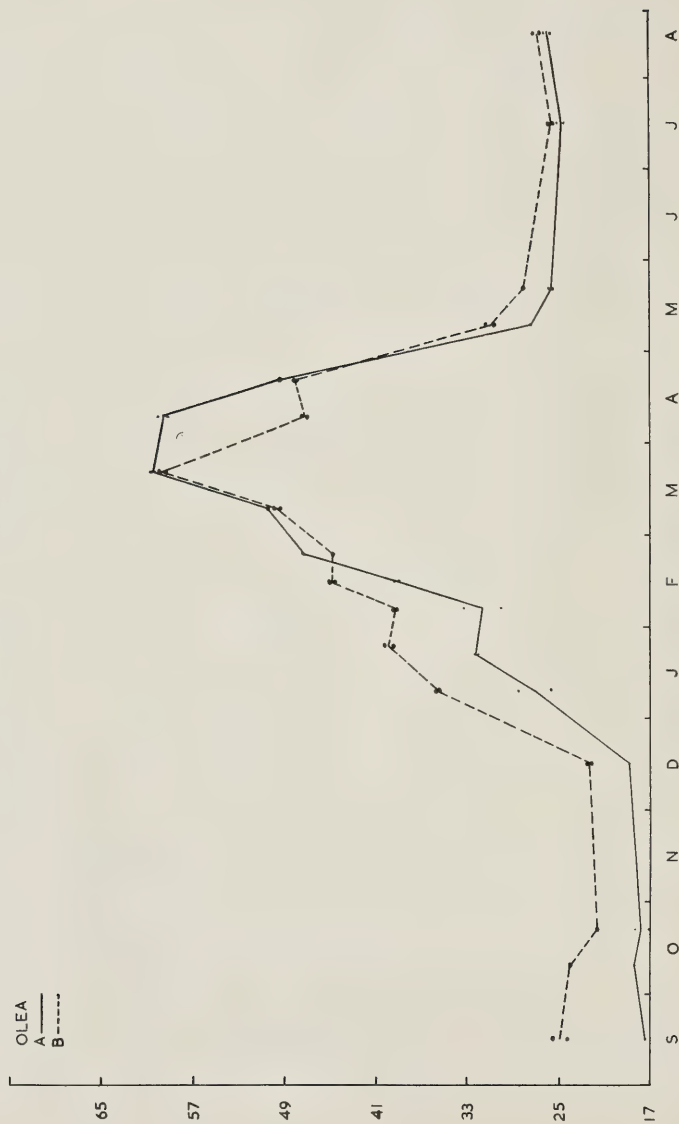


FIG. 5. Osmotic Pressures of *Olea africana* Mill. at foot of dune.

FIG. 6. Osmotic Pressures of *Olea africana* Mill. on top of dune.



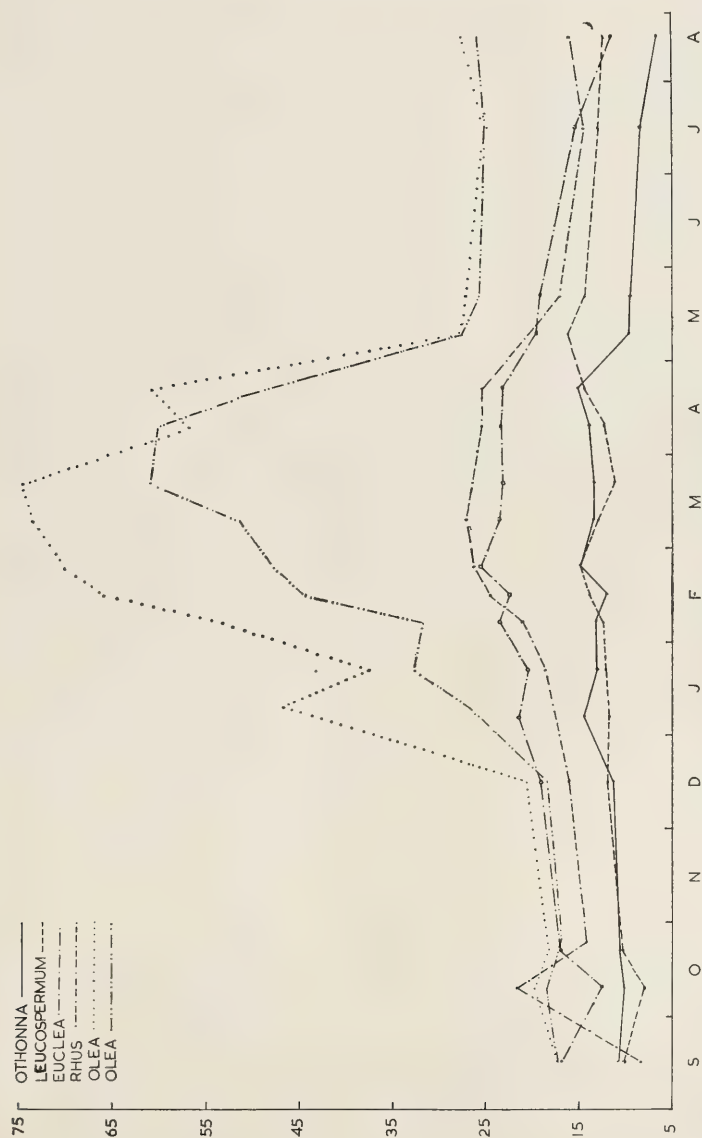


FIG. 7. Comparative graph of Osmotic Pressures.

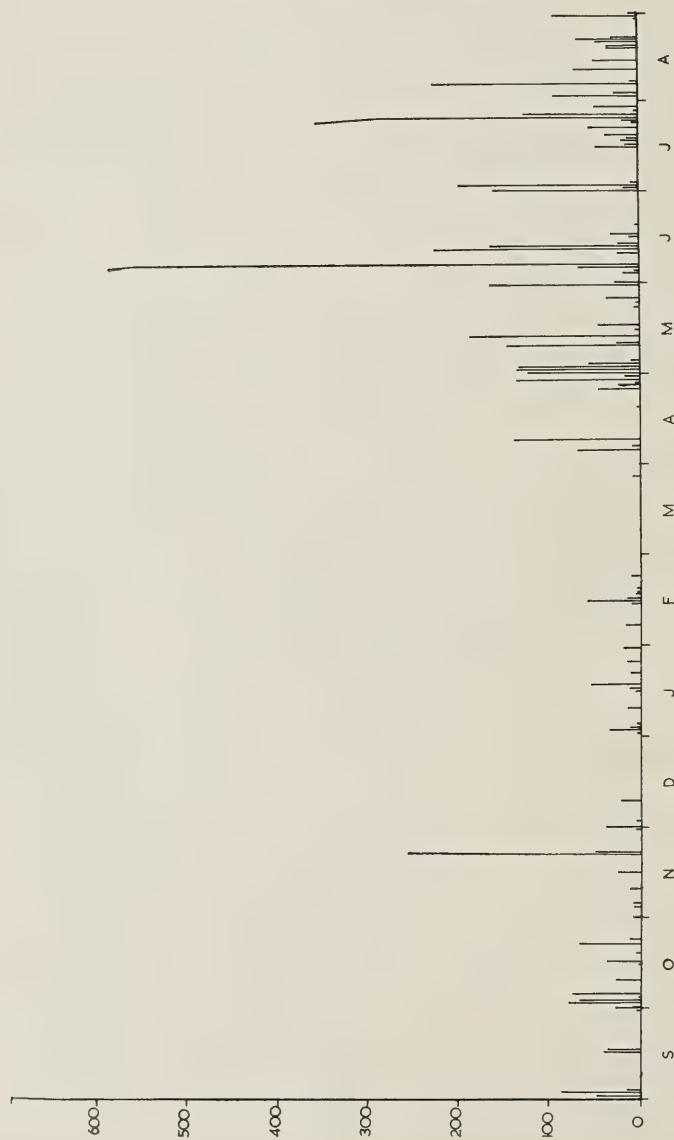


FIG. 8. Rainfall in mm during period of observation.

Most unexpected is the fact that the osmotic pressure of the plant at the foot of the dune was constantly higher than that of the specimen at the top of the dune in spite of its greater exposure to the elements. The latter plant was consistently in a better condition throughout the period of investigation. During October, 1967 this latter plant was in bloom and fruit-bearing during November of the same year. The former plant did not bloom during the period of investigation and the leaves became very hard and slightly curled up during February and March, 1968. The quantity of leaf material collected had in both cases to be increased to yield the required amount of cell-sap for cryoscopy. This unexpected result cannot be explained at present, but the problem is being investigated further.

It is an interesting fact that, with the exception of *O. africana*, there has in each case been a drop in the osmotic pressure during March, 1968, the driest month during the period of observation. This may be due to a considerable number of cool, overcast days with a very slight drizzle when no precipitation could be measured. This seems to show that the roots are in contact with subterranean stores of water which ensure their existence during these dry periods.

The comparative graph in Fig. 7 shows that *O. coronopifolia* and *L. hypophyllum* are hydro-stable, there being relatively little variation in the osmotic pressure. *O. africana*, on the other hand, is hydro-labile with a variation from approximately 16 to 74 atmospheres, while *E. racemosa* and *R. mucronata* occupy a position in between. Furthermore, the active vegetative and reproductive activities occur when the osmotic pressure is comparatively low, but the osmotic pressure of a zerophytic species, such as *O. africana*, never sinks as low as that of a semi-succulent such as *O. coronopifolia*. This again raises the question: which plants are zerophytes? *L. hypophyllum* has leathery leaves with a thick cuticle and well protected stomata, yet the osmotic pressure of its cell-sap is almost as low as that of *O. coronopifolia*. Anatomically it shows characteristics according to which it could be classified as a zerophyte, but the osmotic pressure of its cell-sap is more in accord with that of a mesophyte of Walter (5).

#### SUMMARY

1. Curves of the osmotic pressure of the cell-sap of five indigenous species, on the campus of the U.C.W.C., have been determined for a period of one year.
2. The curves generally show a crest during periods of drought (the summer months) and a trough during the rainy season (the winter months).
3. *Othonna coronopifolia* L. and *Leucospermum hypophyllum* R. Br. are hydro-stable plants, showing a small variation in the osmotic pressure of the cell-sap throughout the year.

4. *Olea africana* Mill. is hydro-labile with a wide variation in the osmotic pressure of its cell-sap.
5. *Euclea racemosa* Murr. and *Rhus mucronata* Thunb. are in between.
6. The specimen of *Olea africana* on top of the dune showed more favourable hydrological conditions than the specimen at the foot of the dune.

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## A REVISED CHECK-LIST OF THE PTERIDOPHYTA OF SOUTHERN AFRICA

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### ABSTRACT

The check-list of the Pteridophyta of Southern Africa, south of the Cunene and Zambesi rivers, published in 1952 is brought up to date. New taxa proposed are *Lycopodium complanatum* subsp. *zanclophyllum* (Wilce) Schelpe, *Pellaea hastata* var. *reticulata* Schelpe, *Pellaea hastata* var. *minor* (Kunze) Schelpe, *Phymatodes ensiformis* (Thunb.) Schelpe and *Woodsia montevidensis* var. *burgessiana* (Gerr. ex Hook. & Bak.) Schelpe.

### INTRODUCTION

Since the publication of the last check-list of the Pteridophyta of Southern Africa, south of the Cunene and Zambesi rivers (Alston & Schelpe, 1952), there has been extensive collecting resulting in new records, new approaches to the classification of the ferns and more intensive work on their taxonomy and nomenclature. Although the present author hopes to publish his monograph on the Southern African Pteridophyta in the near future, there is an obvious need by South African botanists for this revised check-list.

The concepts and arrangement of families and genera is generally in accord with Alston's (1959) treatment of the Pteridophyta for the Flora of West Tropical Africa and follows the present author's treatment of the ferns for the Flora Zambesiaca. Synonyms are given in italics in brackets, and mis-identifications appearing in the earlier check-list are given between quotation marks. Introduced species which have become "weeds" are shown in square brackets.

The author wishes to acknowledge the tenure of a Nuffield Dominion Traveling Fellowship in the Natural Sciences in 1959 and Bremner Travel Grants from the University of Cape Town in 1964 and 1966 without which this revised check-list could not have been accomplished.

### PSILOTALES

#### PSILOTACEAE

*Psilotum* Sw.

*nudum* (L.) Griseb.

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Accepted for publication 7th February, 1969.



## LYCOPODIALES

## LYCOPODIACEAE

**Lycopodium** L.**saurosum** Lam.**gnidioides** L.f.**dacrydioides** Bak.**verticillatum** L.f.**ophioglossoides** Lam.**clavatum** L. var. **inflexum** (Beauv.) Spring**cernuum** L.**complanatum** L. subsp. **zanclophyllum** (Wilce) Schelpe<sup>1</sup>**carolinianum** L.& var. **affine** (Bory) Schelpe& var. **grandifolium** Spring (*L. sarcocaulon* A. Br. & Welw. ex Kuhn)

## SELAGINELLALES

## SELAGINELLACEAE

**Selaginella** Beauv.**pygmaea** (Kaulf.) Alston**caffrorum** (Milde) Hieron.**dregei** (Presl) Hieron.**mittenii** Bak.**kraussiana** (Kunze) A. Br.**abyssinica** Spring**imbricata** (Forsk.) Spring ex Decne.

## ISOETALES

## ISOETACEAE

**Isoetes** L.**giessii** Launert**capensis** Duthie**stephansenii** Duthie**natalensis** Bak.**stellenbossiensis** Duthie

<sup>1</sup> *Lycopodium complanatum* L. subsp. *zanclophyllum* (Wilce) Schelpe comb. nov. et stat. nov.—basionym: *Lycopodium zanclophyllum* Wilce in *Nova Hedwigia* 3: 108, t. 3A, figs. 9–10, t. 3B, figs. 9–10, t. 8 (1961).

**wormaldii** Sim  
**rhodesiana** Alston  
**alstonii** C. F. Reed & Verdcourt

## **EQUISETALES**

### **EQUISETACEAE**

**Equisetum** L.  
**ramosissimum** Desf.

## **OPHIOGLOSSALES**

### **OPHIOGLOSSACEAE**

**Ophioglossum** L.  
**bergianum** Schlechtend.  
**gomezianum** Welw. ex A. Br.  
**costatum** R. Br.  
**nudicaule** L.f.  
**vulgatum** L. var. **kilimandscharicum** Hieron.  
**polyphyllum** A. Br. ex Seubert ("O. *sarcophyllum*")  
**reticulatum** L.

## **MARATTIALES**

### **MARATTIACEAE**

**Marattia** Sw.  
**fraxinea** Sm. ex Gmel. var. **salicifolia** (Schrad.) C. Chr.

## **FILICALES**

### **OSMUNDACEAE**

**Osmunda** L.  
**regalis** L.  
**Todea** Willd.  
**barbara** (L.) Moore

### **SCHIZAEACEAE**

**Schizaea** Sm.  
**pectinata** (L.) Sw.  
**tenella** Kaulf.

**Lygodium Sw.****kerstenii** Kuhn**microphyllum** (Cav.) R. Br. ("L. scandens")**Anemia Sw.****dregeana** Kunze**simii** Tard. emend Alston**angolense** Alston**Mohria Sw.****caffrorum** (L.) Desv.**lepigera** Bak.

## GLEICHENIACEAE

**Gleichenia Sm.****polypodioides** (L.) Sm.**umbraculifera** (Kunze) Moore (*Sticherus umbraculiferus* (Kunze) Ching)**Dicranopteris Bernh.****linearis** (Burm.) Underw.

## HYMENOPHYLLACEAE

**Trichomanes L.****erosum** Willd.& var. **aerugineum** (v.d. Bosch) Schelpe**reptans** Sw. (*T. montanum* Hook.)**pyxidiferum** L. var. **melanotrichum** (Schlechtend.) Schelpe**borbonicum** v.d. Bosch**rigidum** Sw.**Hymenophyllum Sm.****sibthorpioides** (Bory ex Willd.) Mett. ex Kuhn**capillare** Desv.**marlothii** Brause**capense** Schrad. ("*H. fumarioides*")**polyanthos** Sw. var. **kuhnii** (C. Chr.) Schelpe (*H. kuhnii* C. Chr.)& var. **mossambicense** Schelpe**tunbridgense** (L.) Sm.**peltatum** (Poir.) Desv. (*H. uncinatum* Sim)

## CYATHEACEAE

**Cyathea Sm.****mossambicensis** Bak. (*C. holstii* Hieron.)**thomsonii** Bak.

- manniana** Hook. (*C. deckenii* Kuhn)  
**dregei** Kunze  
**capensis** (L.f.) Smith (*Hemitelia capensis* (L.f.) Kaulf.)

MARSILEACEAE

**Marsilea** L.

- coromandelina** Willd. (*M. trichocarpa* Bremek.)  
**ephippiocarpa** Alston  
**apposita** Launert  
**nubica** A. Br.  
**aegyptiaca** Willd.  
**capensis** A. Br.  
**burchellii** (Kunze) A. Br.  
**macrocarpa** (D.C.) Presl  
**farinosa** Launert  
**fenestrata** Launert  
**vera** Launert  
**schelpiana** Launert  
**unicornis** Launert  
**villifolia** Bremek. & Oberm. ex Alston & Schelpe

SALVINIACEAE

**Salvinia** Adans.

- hastata** Desv.  
[**auriculata** Aubl.]

AZOLLACEAE

**Azolla** Lam.

- pinnata** R. Br. var. **africana** (Desv.) Bak.  
**nilotica** Decne. ex Mett.

DENNSTAEDTIACEAE

**Microlepidia** Presl

- speluncae** (L.) Moore

**Hypolepis** Bernh.

- sparsisora** (Schrad.) Kuhn

**Pteridium** Gled.

- aquilinum** (L.) Kuhn  
& subsp. **centrali-africanum** Hieron.

**Blotiella** Tryon**natalensis** (Hook.) Tyron (*Lonchitis natalensis* Hook.)**glabra** (Bory) Tryon (*Lonchitis stenochlamys* Fée)**Histiopteris** J. Sm.**incisa** (Thunb.) J. Sm.

## VITTARIACEAE

**Vittaria** Sm.**isoetifolia** Bory**guineensis** Desv. var. **orientalis** Hieron.**volkensii** Hieron.**elongata** Sw. (*V. hildebrandtii* Hieron.)

## ADIANTACEAE

**Acrostichum** L.**aureum** L.**Ceratopteris** Brogn.**thalictroides** (L.) Brogn. ("*C. cornuta*")**Pityrogramma** Link**argentea** (Willd.) Domin[**calomelanos** (Sw.) Link var. **aureoflava** (Hook.) Weath. ex Bailey]  
(*P. austroamericana* Domin)**Anogramma** Link**leptophylla** (L.) Link**Adiantum** L.**incisum** Forsk. ("*A. caudatum*")**philippense** L.**mettenii** Kuhn ex C. Chr. ("*A. soboliferum*")**mendoncae** Alston**patens** Willd. subsp. **oatesii** (Bak.) Schelpe (*A. oatesii* Bak.)**hispidulum** Sw.**capillus-veneris** L.**aethiopicum** L.**poiretii** Wikstr. (*A. sulphureum* Kaulf.)[**raddianum** Presl]**Pteris** L.**vittata** L.**cretica** L.**dentata** Forsk. subsp. **flabellata** (Thunb.) Runem.**catoptera** Kunze (*P. quadriaurita* Retz.)& var. **horridula** Schelpe



**friesii** Hieron.

**intricata** C. H. Wright

**pteridioides** (Hook.) Ballard

**buchananii** Bak. ex Sim

**hamulosa** Christ (P. *acanthoneura* Alston)

**Cheilanthes** Sw. (including *Notholaena* R. Br.)

**rawsonii** Pappe

**eckloniana** Kunze

**marlothii** Hieron

**inaequalis** Kunze

& var. **buchananii** (Bak.) Schelpe

**leachii** (Schelpe) Schelpe

**capensis** (Thunb.) Sw.

**depauperata** Bak.

**contracta** Mett. ex Kuhn

**hirta** Sw.

**parviloba** Sw.

**induta** Kunze

**dinteri** Brause

**multifida** Sw.

**farinosa** Kaulf.

**mossambicensis** Schelpe

**bergiana** Schlechtend. ex Kunze

**Doryopteris** J. Sm.

**concolor** (Langsd. & Fisch.) Kuhn var. **kirkii** (Hook.) Fries

& var. **nicklesii** (Tardieu) Schelpe

**Pellaea** Link

**pteroides** (L.) Prantl

**deltoidea** (Kunze) Bak.

**robusta** (Kunze) Hook.

**hastata** (L.f.) Link (P. *auriculata* (Thunb.) Fée)

& var. **reticulata** Schelpe<sup>2</sup>

& var. **minor** (Kunze) Schelpe<sup>3</sup>

**viridis** (Forsk.) Prantl

& var. **macrophylla** Sim

& var. **glauca** Sim

& var. **involuta** (Sw.) Schelpe (P. *involuta* Bak.)

<sup>2</sup> *Pellaea hastata* var. *reticulata* Schelpe var. nov. differt a varietate typico, sporis reticulatis. Typus: 5 mls N. from Sutherland *Schelpe* 4948 (BOL).

<sup>3</sup> *Pellaea hastata* var. *minor* (Kunze) Schelpe comb. nov.—basionym: *Cheilanthes profusa* var. *minor* Kunze in *Linnaea* 10: 535 (1836). Syn. *Cheilanthes kunzei* Mett.

- namaquensis** Bak.  
**quadripinnata** (Forsk.) Prantl  
**dolomiticola** Schelpe  
**calomelanos** (Sw.) Link  
     & var. **swynnertoniana** (Sim) Schelpe   (*P. swynnertoniana* Sim)  
**goudotii** (Kunze) C. Chr.  
**longipilosa** Bonap.  
**dura** (Willd.) Bak.  
**doniana** J. Sm. ex Hook.  
**angulosa** (Bory ex Willd.) Bak.  
**boivinii** Hook.  
**rufa** A. Tryon.                               (“*P. andromedifolia*”)  
**Aspidotis** Nutt. ex Hook.  
     **schimperii** (Kunze) Pic. Serm.       (*Hypolepis schimperii* Hook.)  
**Actiniopteris** Link  
     **radiata** (Sw.) Link                   (“*A. australis*”)  
     **dimorpha** Pic. Serm.  
     **pauciloba** Pic. Serm.

## LINDSAEACEAE

- Lindsaea** Dryand.  
     **odorata** Roxb.  
     **ensifolia** Sw.                           (*Schizoloma ensifolia* (Sw.) J. Sm.)

## GRAMMITIDACEAE

- Grammitis** Sw.  
     **magellanica** Desv.                   (*Polypodium magellanicum* (Desv.) Copel.)  
     **nanodes** (A. Peter) Ching  
**Xiphopteris** Kaulf.  
     **serrulata** (Sw.) Kaulf.  
     **flabelliformis** (Poir.) Schelpe   (*Polypodium rigescens* Bory)

## POLYPODIACEAE

- Platyserium** Desv.  
     **alcicorne** Desv.  
     **elephantotis** Schweinf.           (*P. angolense* Welw. nom. inval.)  
**Pyrrosia** Mirb.  
     **africana** (Kunze) Ballard  
     **rhodesiana** (C. Chr.) Schelpe  
     **schimperiana** (Mett.) Alston  
     **lanceolata** (L.) Farwell

**Belvisia** Mirb.**spicata** (L.f.) Mirb.**Loxogramme** Presl**lanceolata** (Sw.) Presl**Polypodium** L.**vulgare** L.**polypodioides** (L.) Hitch. subsp. **ecklonii** (Kunze) Schelpe (*P. ecklonii* Kunze)**vulgare** L.**Phymatodes** Presl**scolopendria** (Burm.) Ching (*Polypodium scolopendria* Burm.f.)**ensifformis** (Thunb.) Schelpe<sup>4</sup>**Pleopeltis** Willd.**macrocarpa** (Willd.) Kaulf. (*Polypodium lanceolatum* L.)**schraderi** (Mett.) Tard. (*Polypodium schraderi* Mett.)**excavata** (Bory ex Willd.) Sledge (*Polypodium excavatum* Bory)**Microgramma** Presl**lycopodioides** (L.) Copel. (*Polypodium lycopodioides* L.)**Microsorium** Link**punctatum** (L.) Copel. (*Polypodium polycarpon* Cav.)**pappei** (Mett. ex Kuhn) Ching (*Polypodium pappei* Mett.)**[scandens** (Forst.) Tindale]

## DAVALLIACEAE

**Nephrolepis** Schott**biserrata** (Sw.) Schott**undulata** (Afz. ex Sw.) J. Sm.**[exaltata** (L.) Schott]**Arthropteris** J. Sm.**orientalis** (Gmel.) Posth.**monocarpa** (Cordem.) C. Chr.**Oleandra** Cav.**distenta** Kunze**Davallia** Sm.**chaerophylloides** (Poir.) Steud.

## ASPLENIACEAE

**Asplenium** L.**holstii** Hieron.**anisophyllum** Kunze

<sup>4</sup> *Phymatodes ensiformis* (Thunb.) Schelpe comb. nov.—basionym: *Polypodium ensiforme* Thunb., Prod. Pl. Cap.: 172 (1800).

- christii** Hieron.  
**boltonii** Hook. ex Schelpe  
**prionitis** Kunze  
**gemmiferum** Schrad.  
**atroviride** Schelpe  
**obscurum** Blume  
**unilaterale** Lam.  
**stoloniferum** Bory (A. kraussii Moore)  
**trichomanes** L.  
**lunulatum** Sw.  
**platyneuron** (L.) Oakes  
**monanthes** L.  
**erectum** Bory ex Willd.  
    & var. **usambarense** (Hieron.) Schelpe  
**lobatum** Pappe & Raws.  
**varians** Wall. ex Hook. var. **fimbriatum** (Kunze) Schelpe  
**auritum** Sw.  
**pumilum** Sw. subsp. **hymenophylloides** (Fée) Schelpe  
**friesiorum** C. Chr.  
**protensum** Schrad.  
**pellucidum** Lam. subsp. **pseudohorridum** (Hieron.) Schelpe  
**formosum** Willd.  
**ramlowii** Hieron.  
**simii** Braithw. & Schelpe  
**lividum** Mett. ex Kuhn  
**aethiopicum** (Burm.) Becherer  
**splendens** Kunze  
**buettneri** Hieron.  
**blastophorum** Hieron. ex Brause  
**torrei** Schelpe  
**linckii** Kuhn  
**sandersonii** Hook.  
**dregeanum** Kunze  
**preussii** Hieron. subsp. **austroafricanum** Schelpe  
**pseudoauriculatum** Schelpe  
**rutaefolium** (Berg.) Kunze  
    & var. **bipinnatum** (Forsk.) Schelpe  
**mannii** Hook.  
**hypomelas** Kuhn (Loxoscaphe nigrescens (Hook.) Moore)  
**theciferum** (HBK) Mett. var. **concinnum** (Schrad.) Schelpe  
    (Loxoscaphe theciferum var. concinnum C. Chr.)

**Ceterach** Gars.

**cordatum** (Thunb.) Desv.

**THELYPTERIDACEAE**

**Thelypteris** Schmid.

- |                                       |  |
|---------------------------------------|--|
| <b>confluens</b> (Thunb.) Morton      | ( <i>Dryopteris thelypteris</i> (L.) Gray)       |
| <b>bergiana</b> (Schlechtend.) Ching  | ( <i>Dryopteris bergiana</i> (Schl.) O. Ktze.)   |
| <b>strigosa</b> (Willd.) Tard.        |  |
| <b>chaseana</b> Schelpe               |  |
| <b>gueinziana</b> (Mett.) Schelpe     | ("( <i>Dryopteris membranifera</i> ")            |
| <b>longicuspis</b> (Bak.) Schelpe     |  |
| <b>dentata</b> (Forsk.) E. St. John   | ( <i>Dryopteris dentata</i> (Forsk.) C. Chr.)    |
| & var. <b>buchananii</b> Schelpe      |  |
| <b>quadrangularis</b> (Fée) Schelpe   |  |
| <b>elata</b> (Mett. ex Kuhn) Schelpe  |  |
| <b>totta</b> (Thunb.) Schelpe         | ( <i>Dryopteris gongylodes</i> (Schk.) O. Ktze.) |
| <b>extensa</b> (Blume) Morton         | ( <i>Dryopteris impressus</i> (Desv.) Posth.)    |
| <b>madagascariensis</b> (Fée) Schelpe | ( <i>Dryopteris silvatica</i> (P. & R.) C. Chr.) |
| <b>pozoi</b> (Lagasca) Morton         | ( <i>Dryopteris africana</i> (Desv.) C. Chr.)    |

**Ampelopteris**

**prolifera** (Retz.) Copel                      (*Dryopteris prolifera* (Retz.) C. Chr.)

**ATHYRIACEAE**

**Cystopteris** Bernh.

**fragilis** (L.) Bernh.

**Athyrium** Roth.

- schimperi** Moug. ex Fée
- scandicinum** (Willd.) Presl
- & var. **rhodesianum** Schelpe

**Diplazium** Sw.

- zanzibaricum** (Bak.) C. Chr.
- nemorale** (Bak.) Schelpe                      (*D. stolzii* Brause)

**Dryoathyrium** Ching

**boryanum** (Willd.) Ching.                      (*Dryopteris kiboschensis* (Hieron.) C. Chr.)

**LOMARIOPSIDACEAE**

**Elaphoglossum** Schott

- acrostichoides** (Hook.) Schelpe                      ("(*E. angustatum*")
- marojejense** Tard.



- angustatum** (Schrad.) Hieron.  
**conforme** (Sw.) J. Sm.  
**lastii** (Bak.) C. Chr.  
**macropodium** (Fée) Moore ("E. isabelense")  
**petiolatum** (Sw.) Urban var. **salicifolium** (Willd. ex Kaulf.) C. Chr.  
**aubertii** (Desv.) Moore  
**hybridum** (Bory) Moore  
**drakensbergense** Schelpe  
**spathulatum** (Bory) Moore  
**chevalieri** Christ  
**kuhnii** Hieron.  
**deckenii** (Kuhn) C. Chr.  
**Lomariopsis** Fée  
     **warneckei** (Hieron.) Alston  
**Bolbitis** Schott  
     **heudelotii** (Bory) Alston (*Leptochilus heudelotii* (Bory) C. Chr.)
- ASPIDIACEAE**
- Woodsia** R. Br.  
     **montevidensis** (Spreng.) Hieron. var. **burgessiana** (Gerr. ex Hook. & Bak.) Schelpe<sup>5</sup> (*W. burgessiana* Gerr.)  
**Didymochlaena** Desv.  
     **truncatula** (Sw.) J. Sm.  
**Dryopteris** Adans.  
     **wallichiana** (Spreng.) Hyl.  
     **manniana** (Hook.) C. Chr.  
     **inaequalis** (Schlechtend.) O. Kuntze (*D. pentheri* (Krass.) C. Chr.)  
     **callolepis** C. Chr.  
     **athamantica** (Kunze) O. Kuntze  
     **kilemensis** (Kuhn) O. Kuntze  
     **squamiseta** (Hook.) O. Kuntze  
**Hypodematum** Kunze  
     **crenatum** (Forsk.) Kuhn (*Dryopteris crenata* (Forsk.) O. Ktze.)  
**Phanerophlebia** Presl  
     **caryotideae** (Wall. ex Hook. & Grev.) Copel. var. **micropteris** (Kunze) C. Chr. (*Cyrtomium caryotideum* var. *micropteris* (Kze.) C. Chr.)  
**Polystichum** Roth  
     **macleanii** (Bak.) Diels

<sup>5</sup> *Woodsia montevidensis* var. *burgessiana* (Gerr. ex Hook. & Bak.) Schelpe comb. nov. et, stat. nov.—basionym: *Woodsia burgessiana* Gerrard ex Hook. & Bak., Syn. Fil., ed. i. 48 (1866).

- luctuosum** Moore  
**lucidum** (Burm.) Becherer  
**zambesiaceum** Schelpe ("P. *ammifolium*")  
**setiferum** (Forsk.) Woynar  
     & var. **fuscopaleaceum** (Alston) Schelpe  
     & var. **stenophyllum** (Bonap.) Alston  
**Arachniodes** Blume  
     **foliosa** (C. Chr.) Schelpe ("Polystichum *aristatum*")  
**Ctenitis** C. Chr.  
     **cirrhusa** (Schum.) Ching (*Dryopteris cirrhosa* (Schum.) O. Ktze.)  
     **lanuginosa** (Willd. ex Kaulf.) Copel. (*Dryopteris lanuginosa* (Willd.) C. Chr.)  
**Tectaria** Cav.  
     **gemmifera** (Fée) Alston  
**Rumohra** Raddi  
     **adiantiformis** (Forst.) Ching (*Polystichum adiantiforme* (Forst.) J. Sm.)

## BLECHNACEAE

- Blechnum** L.  
     **ivohibense** C. Chr.  
     **inflexum** (Kunze) Kuhn  
     **attenuatum** (Sw.) Mett. var. **giganteum** Bonap.  
     **tabulare** (Thunb.) Kuhn  
     **capense** (L.) Schlechtend.  
**Stenochlaena** J. Sm.  
     **tenuifolia** (Desv.) Moore

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## BOOK REVIEWS

RECENT ASPECTS OF NITROGEN METABOLISM IN PLANTS—Edited by E. J. Hewitt and C. V. Cutting. xvi + 280 pages with 29 tables, 81 figures and 14 plates. (Academic Press, London, 1968.) Price £4 4s. 0d.

This book constitutes the proceedings of a symposium held at the Long Ashton Research Station, Bristol, during 1967. The 14 chapters are grouped into three sections.

Section 1 deals with transformations in inorganic nitrogen metabolism and nitrogen fixation. It starts off with an interesting chapter dealing with the fundamental causes for the unusually inert nature of molecular nitrogen. From first principles the authors conclude that the elements of Group VIII, such as Fe, Co or Ni, seem most likely to be the metal used in nature for nitrogen fixation. It will be interesting to see whether future research will substantiate this deduction.

In the second chapter Bond provides a brief but stimulating survey of the symbiotic nitrogen fixing systems. Chapter 3 is devoted to nitrogen fixation in *Anabaena cylindrica*. It is concluded that nitrogen fixation in this blue-green alga is not dependent on ATP or reducing power generated directly by light. The status of hyponitrite and hydroxylamine as possible intermediates in nitrite reduction by plants is reviewed in chapter 4. The authors point out that the latest evidence appears to completely exclude free hydroxylamine as an intermediate in nitrite reduction in higher plants. After a very short paper dealing with the localization of the nitrate reducing enzymes in barley section 1 is concluded with a stimulating chapter on mechanisms involved in the regulation of nitrogen assimilation in micro-organisms and plants.

Section 2 deals with the intermediate metabolism of amino acids and with relationships between mineral nutrition and protein synthesis. In dealing with the metabolism of amino acids in plants, Davies stresses the lack of studies of this nature and cautions against the tendency to assume that the amino acid metabolism of plants is similar to that of animals and micro-organisms. The biosynthesis of putrescine in higher plants and its relation to potassium nutrition is discussed in one chapter whilst another is devoted to some properties of plant diamine oxidase. This section is concluded by a chapter dealing with the specificity of amino acid biosynthesis and incorporation into plant proteins. It is made evident that the study of non-protein amino acids in plants is highlighting a number of problems associated with amino acid and protein biosynthesis such as the organization of amino acid pools and the screening and specific selection of amino acids for incorporation into proteins.

In section 3 some interactions of the nitrogen metabolism of plants and external factors are discussed. Luckwill considers the relations between plant growth regulators and nitrogen metabolism in the first chapter. The second chapter is devoted to deviations in nitrogen metabolism associated with viruses and contains some splendid electron micrographs of plant virus particles. In the third chapter Pate deals with the extensive studies carried out at Queens University, Belfast on the assimilation, transport and utilization of nitrogen in the field pea (*Pisum arvense* L.). The last chapter in the book deals with the effect of climate and time of application of nitrogenous fertilizers on the development and crop performance of fruit trees.

The wide variety of aspects of nitrogen metabolism dealt with in the book, the lucid style in which it is written and the high standard of nearly all the chapters should guarantee it a place on the bookshelf of most plant physiologists. Despite its wide coverage this book, like most symposia, cannot substitute for the comprehensive textbook with its unified treatment of the subject matter and it will therefore not be of general use to undergraduate students.

N. GROBBELAAR

DENDROLOGIA DE MOÇAMBIQUE by A. Gomes e Sousa Vols I and II—Published as a memorias by the Instituto de Investigação Agronomica de Mocambique 1968. Price about R4 per volume.

Dr. Gomes e Sousa is well known to South African Botanists. He has now published this fine two-volume monograph on the trees of Moçambique which is the result of many years of study of the Moçambique flora. Although unfortunately many South Africans do not have much Portuguese, the botanical facts are easily gleaned and Dr. Gomes e Sousa's beautiful illustrations will be of great value in identifying specimens.

*Casuarina equisetifolia* (= *C. africana*) is included. Airey Shaw, however, considers this a questionable record.

ENID DU PLESSIS





## NOTES ON MESEMBRYANTHEMUM AND ALLIED GENERA

H. M. L. BOLUS

**Dorotheanthus booyseii** L. Bol. sp. nov.—Partes herbaceae grosse papillatae; folia spathulata vel subspathulata, parte inferiore ad duplo longiore quam parte superiore vel eam aequante, parte superiore rotundata, ad 1·3 cm. lata; pedunculi 1·5—3 cm. longi; receptaculum 4 mm. longum, 7 mm. diam.; sepala 5, subaequilonga, omnia angustissime marginata, acuta vel obtusa, 5 mm., vel in flore seniore ad 1 cm., longa; petala 3-seriata, sat laxa, acuta vel obtusa, alba vel cum aetate pallide roseo tincta, ad 2·5 cm. longa, ad 3 mm. lata; stamina 3—4-seriata, filamentis antherisque saturate rubris; stigmata 5, gracilia papillata rosea, ad 5 mm. longa; capsula immatura ad 2·5 cm. diam.

Cape Province: "on the farm Voelfontein, owned by Mr. W. A. Booysen, 35 miles N.W. of Sutherland, alt. 4800 ft., Sept. 5, 1968, *H. Hall* 3279. "Several hundred plants were seen, in rather stony ground, thinly dispersed among the sparse vegetation. About ten per cent bore flowers with pale violet-tipped petals. In view of the exceptionally good rains this species did not show the luxuriance usually noted with similar annual species. It grows in association with dwarf, spiny *Eberlanzia*, the shrubby *Euryops lateriflorus*, *Dimorphotheca cuneata* which is so abundant as to resemble patches of snow with their showy flowers, as is similarly observed by the equally abundant white-flowered, dwarf *Heliophila* sp., and an even dwarfer species of *Cotula* or *Cenia* with whitish flowers, all of which tended to camouflage the *Dorotheanthus*. At the elevation of this and neighbouring farms the winters are cold, bleak and windswept. Mr. Booysen informed us that 5 or 6 inches of snow blanketed the area about 10 days previous to our visit, and that several degrees of night frost are normal for the area throughout the winter."

**Dorotheanthus rourkei** L. Bol. sp. nov.—Plantae 7 visae, ad 6 cm. altae, 6—12 cm. diam.; partes herbaceae inconspicue papillatae; folia spathulata vel subspathulata vel fere linearia, 2·5—4 cm. longa, ad 7 mm. lata; pedunculi 1·5—6 cm. longi; receptaculum obconicum, ad 4 mm. longum, ad 5 mm. diam.; vel in fructu ad 1 cm. vel ultra accrescens; sepala 5, obtusa, omnia angustissime marginata, 8—10 mm. longa, basi 2—4 mm. lata; petala 4-seriata, acuta vel acuminata, prope medium latissima, ad 4 mm. lata, saturate rubra, ad 3 cm.

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Accepted for publication 24th March, 1969

longa; stamina 3-seriata, filamentis rubris, 2—3 mm. longis, antheris aureis; stigmata 5, angustissime subulata, 3 mm. longa vel in immatura capsula ad 5 mm. accrescentia.

Cape Province: Namaqualand; "on the Groenrivier Road, between Garies and the Nuwefontein—Kotzesrus area, about 15 miles S. of Garies, 8th Aug. 1967, J. P. Rourke 814. "Growing in sandy patches on an area of about 1 acre in extent. Petals brilliant scarlet. Approximately 36 plants collected."

**Lampranthus tenuis** L. Bol. sp. nov.—Gracillimus glaber, 26 cm. altus; folia fere erecta, acuta, 6—11 mm. longa, vix ad 2 mm. diam; flores solitarii diurni, 1·6—2 cm. diam; pedunculi 5—6 mm. longi; receptaculum obconicum, ad 3 mm. longum, ad 4 mm. diam.; sepala 5, subaequilonga, acuta vel acuminata, 4 mm. longa, interiora marginata; petala 1—2-seriata, inferne leviter angustata, subobtusata, pallide purpureo rosea, ad 9 mm. longa, ad 1·5 mm. lata; staminodia tenuissime capillacea, saturate rubra, ad 4 mm. longa; stamina 3—4-seriata, filamentis parum supra medium papillatis, antheris luteis; discus crenulatus; stigmata 5, prope apicem leviter angustata, viridia, 2·5 mm. longa.

Cape Province: Cape Peninsula; Kenilworth Race Course, Sept. 1968, E. Esterhuysen 32044. "Amongst low bush on small hillocks in marshy area near *Elegia verreauxii* and *Chondropetalum rectum*. Erect or falling over, rather slender, not much more than 1 ft. tall. Propagating, easily from shoots falling to the ground and rooting."

**Cephalophyllum francisci** L. Bol. sp. nov.—Planta integra 1 visa, glabra, 9 cm. alta, 18 cm. diam.; flores 12 ferens, caule lignoso, 1 cm. longo diametroque et 4 rami floriferi, ad 11 cm. longi, caule ad 3 cm. longo, ad 1 cm. diam.; folia erecta vel demum patentia, acuta apiculata, ad 8 cm. longa, 7 mm. lata diametroque, vagina 5 mm. longa; pedunculus 1-fl., prope basim bracteatus, bracteis 1·5—2 cm. longis, vagina ad 6 mm. longa; receptaculum 4—8 mm. longum, diam., 1 cm.; sepala 5, exteriora 2 longe acuminata, apiculata 1·1 cm. longa, 8 mm. lata, interiora obtusa, late membranaceo marginata, 7—10 mm. longa, 7—8 mm. lata; petala 3-seriata, inferne leviter angustata, obtusa vel leviter emarginata, laete roseo purpurea, 2—3 cm. longa, 2—3 mm. lata; stamina ad 4-seriata, filamentis gracillimis, pallide roseis, ad 5 mm. longis, antheris saturate rubre brunneis, ad 1·5 mm. longis; ovarium leviter elevatum; stigmata 12, intus longe hispida, pallide rosea, ad 5 mm. longa; discus crenulatus.

Cape Province: in dit. Clanwilliam; Elandsvlei, near Cedarberg, Aug. 1968, F. J. Stayner. Karoo Garden 237/68.

Note.—The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.

(To be continued)

## NOTES ON THE GENUS DELOSPERMA (MESEMBRIAE)

M. LAVIS

**Delosperma guthriei** Lavis sp. nov. (*Angulatipedes*).—Planta glabra, primo caespitosa, demum ramos ad 62 cm. longos emittens, internodiis saepius 1—3 cm. longis, 1—4 mm. diam.; folia ascendentia vel fere erecta vel rare recurva, triangularia apiculata, 2 cm. longa, 4 mm. lata diametroque, vel ad 4.5 cm. longa, 10 mm. lata, vagina brevissima; flores solitarii diurni pentameri, 2.6 cm. diam.; pedunculus superne angulatus, ad 2 cm. longus; sepala acuminata subaequilonga, ad 1.3 cm. longa, interiora marginata; petala ca. 4-seriata, inferne leviter angustata, obtusa vel emarginata, nivea, ad 10 mm. longa, ad 1.5 mm. lata; staminodia superne recurva; stamina 3-seriata, filamentis albis, intimis prope medium papillatis, antheris luteis; glandulae approximatae crenulatae; ovarium obtuse lobatum, lobis glandulas non attingentibus; stigmata subulata breviter caudata, 3 mm. longa.

Cape Province: in dit. Caledon; Mossel River, Poole's Bay near Hermanus, Feb. 1920, *F. Guthrie*. N.B.G. 76/20.

**Delosperma saxicolum** Lavis sp. nov. (*Augustifolia*).—Plantae 2 visae, caespitosae, 4 cm. altae, ad 11 cm. diam.; partes herbaceae glabrae politae; folia ascendentia vel demum patentia, linearia acuta, minute apiculata, 1.3—1.7 cm. longa, 6—7 mm. lata, ad 6 mm. diam.; flores solitarii diurni, subsessiles vel pedunculi ad 6 mm. longi, bracteis 5—13 mm. longis; receptaculum obconicum, ad 3 mm. longum; sepala 5, subaequilonga apiculata, interiora membranaceo marginata, 5 mm., vel in floribus majoribus, 7 mm. longa, 2 mm. lata; petala 2-seriata, sat laxa, inferne leviter angustata pallidaque, superne pulchre rosea, ad 1 cm. longa, 1 mm. lata; stamina 9—10-seriata, filamentis albis, antheris pallide luteis; glandulae conspicuae; ovarii lobi erecti approximati, fere ad 1 mm. alti; stigmata 5, subulata viridia, cum cauda breve 2 mm. longa.

Cape Province: in dit. Humansdorp; about 10 miles south of Settlement at Storms River National Park. On cliffs 100—200 ft. above the coast. Amongst low fynbos bush. "Petals pale pink". 10 miles south of the mouth of Storms River, Oct. 1968, *E. Esterhuysen* 32049.

**Delosperma roseopurpureum** Lavis sp. nov. (*Papillosa*).—Planta integra non visa; rami florentes 15 visi, ad 17 cm. longi, internodiis 0.7—4.5 cm. longis, ad

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Accepted for publication 24th March 1969.

3 mm. diam.; partes herbaceae papillatae virides; folia erecta vel ascendentia, fere semiteretia vel leviter canaliculata, lateraliter visa obtusa, 2·5—5 cm. longa, ad 4 mm. lata diametroque; flores pentameri diurni, demum laxe cymosi, cymis 2—6-fl.; pendunculi 2—3 cm. longi; receptaculum obconicum, 8 mm. longum, ad 9 mm. diam.; sepala exteriora subobtusata, ad 1·1 cm. longa, interiora patentia, sat anguste marginata, ad 6 mm. longa; petala sat dense 3—4-seriata, omnia purpureo—rosea, ad 1·9 cm. longa, ad 1·5 mm. lata; staminodia exteriora superne recurva, purpureo—rosea, ad 7 mm. longa, stamina 4—7 mm. longa, filamentis intimis prope medium papillatis; glandulae crenulatae conspicuae, sat distantes; ovarium supra obtuse lobatum, lobis glandulas attingentibus; stigmata subulata, ad 3·5 mm. longa cum cauda 0·75 mm. longa.

Orange Free State: in dit. Ladybrand; near Ladybrand, 1917, *M. M. Page*. N.B.G. 3006/17. Fl. Jan. 1918. Collected again by *Miss Page*. Moriza, Basutoland, May 1919.

The following are the 29 sections into which the genus *Delosperma* N. E. Br. Gard. Chron. 78:273 (1925) has been divided, arranged chronologically:—*Delosperma*, *Angustifolia*, *Planifolia*, *Tropica*, *Cymosa*, *Carinata*, *Compressilatera*, *Quadrifidum*, *Eximia*, *Papillatipetalum*, *Tholiforme*, *Gracillimum*, *Teretifolia*, *Multipetalum*, *Alticola*, *Anularia*, *Decorticans*, *Papyraceitunicatum*, *Setiferipapillatum*, *Gibbosum*, *Angulatipedes*, *Reptans*, *Crassifolium*, *Bicarinatireceptaculum*, *Spathulatipetalum*, *Androstenum*, *Eckloniana*, *Papillosa*, *Sparsipetalum*. The first section *Delosperma* was described in Jl S. Afr. Bot. 33:313 (1967).

**Angustifolia** Lavis sect. nov.—Plantae humilis, caespitosae; radix tuberosa vel lignosa; partes herbaceae glabrae, saepissime viridia, papillosae, papillis rare setiferis; rami 8—27 cm. longi, internodiis 0·6—7 cm. longis, ad 3 mm. diam.; folia patentia, ascendentia vel erecta, vel interdum demum recurvata, supra plana vel concava 1·5—2·7 cm. longa, ad 3 mm. diam.; flores saepius solitarii, vel, interdum 2—3-nati et subcymosi, diurni; pedunculi subnulli, vel ad 7 cm. longi; receptaculum saepe turbinatum, ad 4 mm. diam.; sepala 5, lata; petala 1—4-seriata, linearia, obtusa vel denticulata, nivea, pallide rosea vel atro-purpurea rare lutea ad 12 mm. longa, ad 1·75 mm. lata; staminodia saepissime addita, filiformia vel petaloidea, stamina excedentia, alba, pallide lutea vel saturate rosea, interdum ciliatipapillata, ad 7 mm. longa, stamina 2—5-seriata, filamentis albis, pallide vel saturate roseis, vel luteis ad 5 mm. longa, antheris albis vel stramineis; glandulae inconspicue approximatae vel distantes conspicuae, stigmata 5, subulata, cum cauda 1·5—2·5 mm. longa.

Lectotype. *Delosperma brevipetalum* L. Bol. "Mesemb." 2:152 (1929).

Cape Province: in dit. Albany, prope Grahamstown, Mr. Jolly's farm, Oct. 1928, *Dyer* 1653.



General Distribution: Cape Province, Eastern Province, Lesotho (Basutoland), Orange Free State, Natal and the Transvaal. Localities range from river mouths to mountain heights, the greatest altitude recorded being 9,000 ft., *Delosperma nubigenum* (Schltr.) L. Bol. Habitats are of various description, rocky, sandy, maritime and grassland. The number of named species in this section is 50, roughly divided as follows: Zululand, one; Natal, 5; Transvaal, 6; Orange Free State, 7; Lesotho, 6; Cape Province, 8; the most westerly being *Delosperma macrostigma* L. Bol. from Riversdale and Swellendam vicinity. The remainder (17) come from the Eastern Province. These species are all slender and small flowered, delicate and graceful.

**Planifolia** Lavis sect. nov.—Plantae decumbentes vel reptantes, glabrae et politae; radice fibrosae; rami graciles, ad 30 cm. longi, internodiis 0·5—5 cm. longis, 0·5—4·5 mm. diam.; folia patentia vel adscendentia, supra plana ovata, acuta vel acuminata, sessilia vel subpetiolata, lamina ad 3·5 cm. longa; flores solitarii, subsessiles vel pedunculi ad 4 mm. longi; sepala 5, crassa interdum valde inaequalia; petala 3—4-seriata, obtusa vel acuta, purpureo rosea vel pallida ad 1·3 cm. longa, ad 1·5 mm. lata; staminodia pauca, 6—7 mm. longa; stamina ad 7-seriata, filamentis interioribus saepe papillatis, glandulae distinctae vel quasi subcoalescentes; ovaria lobis erecti vel patentes et glandulas attingentes; stigmata 5, subulata, 2—4 mm. longa.

Lectotype. *Delosperma tradescantioides* (Berger) L. Bol. in Fl. Pl. S. Afr. VII:261 (1927).

Eastern Province: in dit. Kentani, Quolora Valley, Dec. 14, 1905, *Miss Alice Pegler* 1285. "Trailing over hillsides, flowers white, occasionally magenta".

The other species in this section *D. lebomboense* (L. Bol.) Lavis in Jl S. Afr. Bot. 33:314 (1967) is recorded in the Bolus Herbarium from Lebombo, Zululand, N.E. corner of the Transvaal, Natal and Swaziland.

*D. saxicolum* was described from fresh material; *D. guthriei* and *D. roseo-purpureum* from drawings by *Miss M. M. Page* and dried material.

*Note:* The type specimens of all new species described in this paper are in the Bolus Herbarium, University of Cape Town.





## STUDIES IN THE XYLARIACEAE:

### V. EUHYPOXYLON

P. MARTIN

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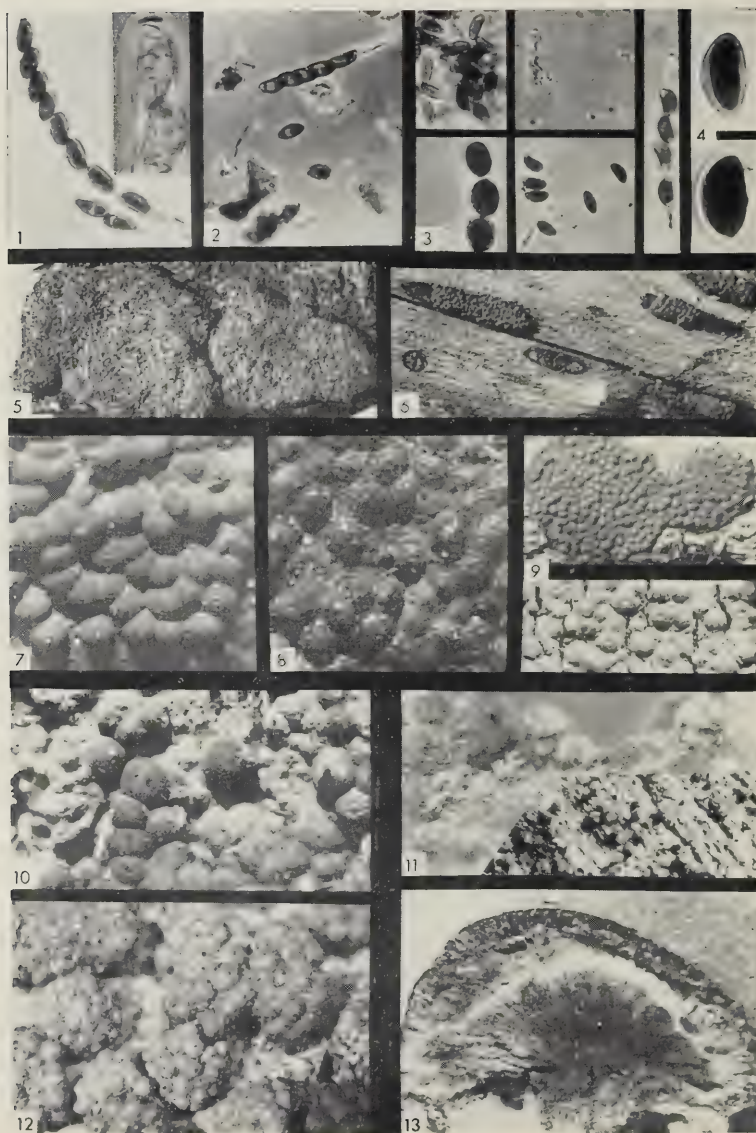
#### INTRODUCTION

The members of this group are more closely related to each other than are those in the previous groups just discussed and there is also a larger number of them. Thus the classification of the species has been sometimes based on extremely fine characters, resulting in much confusion. Theissen (1909) has suggested that on account of similarities in colouration and stromal morphology one species only should be recognized, though with several varieties. Miller (1933) contested this view, pointing out that different geographical distributions of the various types throughout the world provided strong evidence for speciation. The writer considers that broad differences in superficial colouration and other morphological characters may also be used judiciously to delimit 4 subgroups:

- a) The Oodes series (6 spp.) (p. 155)  
Stromata rosellinioid; colouration as in *a*) or *b*).
- b) The Rubiginosum series (9 spp.) (p. 167)  
Stromata restricted; surface some shade of grey-brown, red or purple with matching subsurface colouration.
- c) The Hypomiltum series (13 spp.) (p. 184)  
As above, but with surface or subsurface bright coloured.
- d) The Fragiforme series (6 spp.) (p. 198)  
Stromata massive as in *Daldinia*; colouration as in *b*).

The first and last groups are linked by sporadic development of *Graphium*-type coremia.

Discoïd ascus plugs (Plate I:1) and umbilicate ostioles characterize the group as a whole. When the ostioles are raised on perithecial projections they often appear papillate. The latter character undoubtedly led Miller (1961 p. 46) to place *Hypoxylon croceum*, *H. rutilum* and *H. novemexicanum* in the Papillata group. Conversely, his inclusion of *H. sassafras* in Euhypoxylon is also wrong



because its stromal characters as a whole conform to those of *Entoleuca*, in spite of the presence of depressed ostioles. In two further species (*H. oodes*, *H. riograndense*) however, the ostioles may be actually papillate but their other characters conform closest to the *Euhypoxylon* group. (See Plate I: 7-12)

## KEY TO THE SPECIES

	Stromata without evident coloration at maturity, either superficially or on microscopic examination; predominantly grey or grey-brown .. .. .	2
1'	Surface or interior of stromata coloured .. .. .	3
2	Spores $5.5-6.5 \times 11.5-14.0\mu^*$ Conidiophores in culture <i>Sporothrix</i> I—II: <i>Hypoxylon plumbinum</i> Martin, nov. sp. (p. 167)	
2'	Spores $8.5 \times 27.0\mu$ <i>Hypoxylon macrosporum</i> Karsten (p. 168)	
3 (1)	Surface of stroma deep blue, spores $4.5 \times 8.0\mu$ <i>Hypoxylon aeruginosum</i> Miller	
3'	Surface of stroma olive green, spores $5.0 \times 11.5\mu$ <i>Hypoxylon viridicolor</i> Martin, nov. sp. (p. 187)	
3''	Surface of stroma white superficially, later dull; interior vinaceous or orange	13
3'''	Surface of stroma differently coloured .. .. .	4

\*Figures expressed to the first place of decimals, represent averages of a set of measurements; integers only, the mere range of dimensions.

## PLATE I Stromata and spores.

1. Ascus of *Hypoxylon fuscum*, showing discoid apical plugs  $\times 210$ ; inset  $\times 540$ .
2. *Hypoxylon occidentale*: refractive (vinaceous) ectostromal particles and ascospores in squash mount  $\times 210$ .
3. Ascospores,  $\times 210$ : upper left: *Hypoxylon murcidum*  
lower left: *Hypoxylon sphaeriosporum*  
upper centre: *Hypoxylon dieckmanni*  
lower centre: *Hypoxylon albostigmatosum*  
right: *Hypoxylon rubiginosum*
4. Detail of ascospores,  $\times 540$   
upper: *Hypoxylon fuscum*, typical of *Euhypoxylon*  
lower: *Hypoxylon rubrostromaticum*, with gelatinous spore sheath
- 5—13 Stromata and associated structures
5. *Hypoxylon novemexicanum*,  $\times 2$ . White mealy ectostroma
6. *Hypoxylon plumbinum*,  $\times 2$ . Smooth surface, indistinct ostioles
7. *Hypoxylon murcidum*,  $\times 10$ . Minute papillate or umbilicate ostioles
8. *Hypoxylon occidentale*,  $\times 10$ . Granulate surface, indistinct raised ostioles
9. Characteristic umbilicate ostioles in upper, *Hypoxylon ferrugineum*  $\times 2$   
lower, *Hypoxylon fuscum*  $\times 5$
10. *Hypoxylon oodes*,  $\times 10$ . Loosely coalesced perithecia in all stages of development, some with papillate ostioles
11. *Hypoxylon oodes*. Coremia in side view,  $\times 20$ .  
Inset: surface view of coremia,  $\times 10$ .
12. *Hypoxylon multiforme* (Papillata group),  $\times 5$ . Strongly papillate ostioles for comparison with above.
13. *Hypoxylon sclerophaeum*,  $\times 5$ . Longitudinal section of stroma showing massive basal tissue.

- 4 Ectostromal interior dull, brown, red or red-vinaceous, at sight or in microscopical examination; stromata never massive in construction; spores sometimes with hyaline sheaths . . . . . 5
- 4' Ectostromal interior brightly coloured, yellow, orange or lateritic, at sight or in microscopical examination; stromata variable, sometimes massive in construction . . . . . 15
- 5 Stromata erumpent, ostioles usually wide mouthed and periphysate; surface of stroma brown or olivaceous brown, interior dark; spores  $5.0-6.5 \times 10.0-12.0\mu$   
Conidiophores in culture: *Sporothrix* II:  
*Hypoxyton ferrugineum* (Oth.) Miller (p. 169)
- 5' Stromata superficial, if occasionally erumpent then surface at least partially red . . . . . 6
- 6 Stromata containing from one to many perithecia evident in outline or loosely coalesced; surface colour variable, red brown to lilac, purple or violaceous . . . . . 7
- 6' Stromata multiperitheciate or rarely uniperitheciate as well; perithecia with a greater degree of coalescence; surface colour red brown to purple-maroon . . . . . 8
- 7 Stromata lilac to dull red brown; ostioles umbilicate or occasionally papillate, black and sometimes conspicuous against the rest; *Graphium*-type coremia often present; initial stage dull red; spores dark brown,  $4.0-6.5 \times 9.5-12.5\mu$   
Conidiophores in culture: *Sporothrix* I—III  
*Hypoxyton oodes* Berk. & Br. (p. 155)
- 7' Stromata reddish brown; ostioles umbilicate or slightly raised, but not conspicuous; conidial stage hyphomycetous, initial stage bright coloured, varying from salmon pink to yellow brown; spores usually dark,  $4.0-5.5 \times 9.5-11.0\mu$   
Conidiophores in culture: *Sporothrix* IV—V  
*Hypoxyton croceum* Miller (p. 159)
- 7'' Stromata purple red or violaceous, ostioles umbilicate or slightly raised but not conspicuous; conidial stage hyphomycetous, initial stage dull red, spores amber to pale brown,  $3.5-5.5 \times 7.0-13.0\mu$   
Conidiophores in culture: *Sporothrix* IV—V  
*Hypoxyton riograndense* Rehm (p. 161)
- 8 (6) Spores usually amber or pale brown, if dark then narrow navicular; perithecia adjacent to close crowded, rarely compacted, sometimes developing individually within a common stromal matrix; ostioles sometimes papillate . . . . . 9
- 8' Spores medium or dark brown, fairly broad, if lighter then perithecia compact; perithecia normally closely associated and not usually separate, ostioles never papillate . . . . . 10
- 9 Stromata purple-red or violaceous, ostioles umbilicate, slightly raised but not conspicuous; initial stage dull red, spores  $3.5-5.5 \times 7.0-13.0\mu$   
Conidiophores in culture: *Sporothrix* IV—V  
*Hypoxyton riograndense* Rehm (p. 161)
- 9' Stromata deep purple-red, ostioles poroid umbilicate or minutely papillate; initial stage bright yellow; spores  $5.0-5.5 \times 11.0-12.5\mu$   
Conidiophores in culture: *Sporothrix* I—II  
*Hypoxyton murcidum* Berk. & Br. (p. 163)
- 10 (8) Spores oval to subglobose, at least one half as wide as long, equilateral,  $5.5 \times 9.5-10.5 \times 17.0\mu$ , dark brown to black; stroma pulvinate to applanate with red purple surface.  
*Hypoxyton sphaeriosporum* Martin nov. sp. (p. 176)
- 10' Not with this character combination, spores not subglobose . . . . . 11



- 11 Stromata deep purple red, crustose, fairly effuse, ostioles indistinct, perithecia compact; spores pale to dark brown,  $3.5-4.5 \times 7.5-9.0\mu$   
Conidiophores in culture: *Sporothrix* IV  
*Hypoxylon dieckmanni* Theissen (p. 170)
- 11' Stromata purple-brown to purple-red, not usually effused, often with white periphysate ostiolar mouths; spores pale to medium brown, subhyaline or opaque,  $4.5-6.0 \times 9.5-12.0\mu$   
Conidiophores in culture: *Sporothrix* I—II  
*Hypoxylon rubiginosum* Pers. ex Fr. (p. 172)
- 11'' Stromata pale purple-red to purple-grey, usually compact, ostioles white or indistinct; spores dark brown,  $6.0-8.5 \times 13.0-14.5\mu$   
Conidiophores in culture: *Sporothrix* II  
*Hypoxylon vogesiacum* Pers. ex Sacc. (p. 176)
- 11''' Stromata deep purple red to maroon, spores dark brown, usually fairly large; conidiophores in culture: *Sporothrix*—*Acrostaphylus* 12
- 12 Ectostroma dull vinaceous; spores naked,  $5.5-9.5 \times 10.5-25.0\mu$   
Conidiophores variable in culture: *Sporothrix* I—II, and IV  
*Hypoxylon fuscum* Pers ex Fr. (p. 178)
- 12' Ectostroma yielding conspicuous vinaceous particles on microscopic examination; spores with conspicuous hyaline sheaths,  $6.5-9.5 \times 13.0-20.0\mu$   
Conidiophores in culture: *Acrostaphylus*  
*Hypoxylon rubrostromaticum* Miller (p. 182)
- 13 (3) Interior of ectostroma deep yellow-orange at sight; usually refractive; spores  $4.0-6.5 \times 8.0-13.0\mu$   
Conidiophores in culture: *Sporothrix* II, IV—V  
*Hypoxylon bicolor* E. & E. (p. 184)
- 13' Interior of ectostroma dark at sight, vinaceous or orange on microscopic examination
- 14 Spores  $5.5-6.0 \times 10.0-13.0\mu$  14  
*Hypoxylon argillaceum* Pers. ex Berk.
- 14' Spores  $7.0-8.0 \times 15.5-17.0\mu$   
Conidiophores in culture: *Sporothrix* IV  
*Hypoxylon novemexicanum* Miller (p. 189)
- 15 (4) Stromata glomerular to effuse but usually without well developed basal tissue, never hemispheric or massive in construction 16
- 15' Stromata large, globose, hemispheric or planoconvex with massive basal tissue as in species of *Daldinia*; if applanate then basal tissue exceeds one-half the height of the stroma 25
- 16 Ectostroma corky, not greatly refractive; stromata usually small pulvinate or globose, containing one to many perithecia evident in outline or loosely coalesced 17
- 16' Ectostroma brittle and refractive; stromata rarely uniperitheciate 18
- 17 Stromal surface dull yellow brown; interior yellow; spores  $6.0 \times 12.5\mu$   
*Hypoxylon notatum* B. & C.
- 17' Stromal surface orange to orange brown; interior orange; spores  $7.0 \times 15.5\mu$   
Conidiophores in culture: *Sporothrix* III  
*Hypoxylon aureostroma* Martin nov. sp. (p. 166)
- 18 (16) Stromata with lateritic orange, orange yellow or yellow surface 21
- 18' Stromata with brown, red or red-purple surface 19
- 19 Stromata pulvinate to applanate, crustose, with characteristic granulate maroon purple surface; conidia profuse and rapidly formed in culture; ascospores  $4.0-5.5 \times 9.5-11.5\mu$   
Conidiophores in culture: *Sporothrix* II  
*Hypoxylon occidentale* Ellis & Morgan ex Martin (p. 191)

- 19' Stromata as above but smooth and varying to red brown; conidia as above; ascospores  $4.0-5.5 \times 9.0-12.0\mu$   
Conidiophores in culture: *Sporothrix* I, III  
*Hypoxyton subchlorinum* Ellis & Calkins (p. 192)
- 19'' Stromata and conidia as for preceding species; ascospores varying to black  $4.5-5.5 \times 9.5-12.5\mu$ . Entostroma often disintegrates after maturity.  
Tropical distribution (Central & S. America)  
Conidiophores in culture: *Sporothrix* II  
*Hypoxyton albostigmatosum* Spegazzini (p. 190)
- 19''' Stromata usually rather restricted, pulvinate or aplanopulvinate, smooth; entostroma solid; conidia otherwise . . . . . 20
- 20 Surface purple-red to yellow or rusty brown; spores  $4.0-6.5 \times 8.0-13.0\mu$   
Conidiophores in culture: *Sporothrix* II, IV—V  
*Hypoxyton bicolor* E. & E. (p. 184)
- 20' Surface dull purple-red; spores  $7.0-8.0 \times 15.5-17.0\mu$ , strongly inequilateral  
Conidiophores in culture: *Sporothrix* III  
*Hypoxyton novemexicanum* Miller (p. 189)
- 20'' Surface purple-red; spores  $5.0-10.0 \times 10.0-23.5\mu$   
Conidiophores in culture: *Sporothrix* II  
*Hypoxyton croceoplum* B. & C. (p. 188)
- 21 (18) Perithecial vertices sharply conical, often raised above the stromal surface; spores  $4.0-4.5 \times 7.5-8.0\mu$ . Preference for *Fagus* wood.  
*Hypoxyton rutilum* Tul.
- 21' Perithecial vertices usually not raised, if so then rounded . . . . . 22
- 22 Perithecia close crowded in the stromata, elongate ovate to tubular, easily separating; stromata rapidly disintegrating after maturity leaving orange fragments; spores  $6.0-7.0 \times 12.0-15.0\mu$   
Conidiophores in culture: *Acrostaphylus*  
*Hypoxyton haematostroma* Mont. (p. 195)
- 22' Perithecia close crowded or adjacent, oval to globose, not easily separable; stromata persistent; spores smaller . . . . . 23
- 23 Stromata yellow to yellow orange, usually restricted in size; spores  $4.0-6.5 \times 8.0-13.0\mu$   
Conidiophores in culture: *Sporothrix* II, IV—V  
*Hypoxyton bicolor* E. & E. (p. 184)
- 23' Stromata lateritic orange, usually effuse . . . . . 24
- 24 Spores  $3.5-4.0 \times 7.0-9.5\mu$ ; conidiophores: *Acrostaphylus*  
*Hypoxyton jecorinum* Berk. & Rav. (p. 196)
- 24' Spores  $4.0-6.0 \times 8.0-12.0\mu$ ; conidiophores in culture: *Sporothrix* II, IV, fertile branches verticillate and often narrowing distally as in *Trichoderma*  
*Hypoxyton hypomiltum* Mont. (p. 193)
- 25 (15) Stromata globose, hemispheric or small pulvinate, with well developed black basal tissue and orange brown ectostroma. With *Graphium* coremial stage in circlet around stroma . . . . . 26
- 25' Stromata aplanopulvinate, planoconvex or large pulvinate . . . . . 27
- 26 Spores  $5.0-6.5 \times 11.0-13.0\mu$   
Conidiophores in culture: *Sporothrix* II  
*Hypoxyton fragiforme* (Pers. ex Fr.) Kickx (p. 198)
- 26' Spores  $3.5-5.0 \times 7.5-9.5\mu$   
Conidiophores in culture: *Sporothrix* II  
*Hypoxyton howeianum* Peck (p. 200)
- 27 (25) Stromal surface bright coloured, saffron to orange yellow; ectostroma yellow; entostroma corky. Spores  $3.5 \times 8.5\mu$   
Conidiophores in culture: *Sporothrix* II  
*Hypoxyton daldiniforme* Martin nov. sp. (p. 202)

- 27' Stromal surface coloured otherwise; ectostroma not visibly coloured; entostroma rigid, sometimes with a degree of carbonization . . . . . 28
- 28 Stromal surface brown; ectostroma refractive, deep orange; spores  $6.0 \times 12.5\mu$   
*Hypoxylon mulleri* Mill.
- 28' Stromal surface dark brown to purple; ectostroma refractive, vinaceous; spores  $5.5-8.0 \times 11.0-17.0\mu$   
 Conidiophores in culture: *Acrostaphylus*  
*Hypoxylon sclerophaeum* Berk. & Curt. (p. 202)
- 28'' Stromal surface yellow ochre, yellow orange or greenish-brown; ectostroma refractive, yellow; spores  $7.5-8.0 \times 12.5-16.0\mu$   
*Hypoxylon papillatum* E. & E.

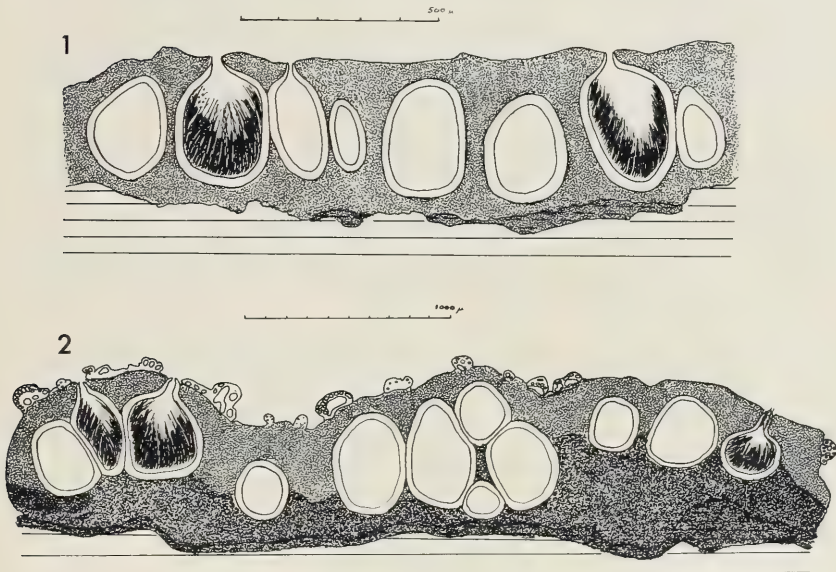


FIG. I. Stromata in vertical section.

1. *Hypoxylon sphaeriosporum*, interior concolorous.
2. *Hypoxylon fuscum*, differentiated into light exterior and darker interior, corresponding roughly to ectostroma and entostroma.

### The Oodes Series.

Members of this group bear certain resemblances to the *Entoleuca* and *Papillata* groups. In contrast to the next two series, the species are relatively easy to distinguish.

#### 1. *Hypoxylon oodes* Berk. & Br. (Plate I: 10, 11)

- Berkeley M. J. & C. E. Broome Jour. Linn. Soc. **14**, 122, (1873). Cooke M. C. Handbook of Australian Fungi 295, (1892). Miller J. H. Monog. Univ. Puerto Rico B. **2**, 203, (1934). World Species of *Hypoxyton* 21, (1961). Petch T. Ann. roy. bot. gard. Perad **8**, 157, (1924).
- sub *Hypoxyton lenormandi* Berk. & Curt.  
Berkeley M. J. Jour. Linn. Soc. **10**, 385, (1869).
- sub *Rosellinia calami* Henn.  
Hennings P. Hedwigia **42**, (79), (1903).
- sub *Rosellinia melaleuca* E. & E.  
Ellis J. B. & B. M. Everhart Bull. Lab. Nat. Hist. Univ. Iowa **2**, 402 (1893).
- sub *Rosellinia molleriana* Hennings non Winter  
Hennings P. Hedwigia **41**, 13, (1902). Rehm H. Leaflets.  
Philipp. Bot. **6**, 1937, (1913); Ibid **8**, 2941, (1916).  
Rick J. Brotéria Ser. cienc. nat. **1**, 188, (1932). Theissen F. Beih. Bot. Cent. **27**, 395, (1910).

Stromata globose to pulvinate or aplanate depending on the degree of association of perithecia,  $0.4-16 \times 0.4-43 \times 0.5-1.5$  mm. Surface of stroma white, dull pink, vinaceous, fawn, reddish brown, or burgundy colour, with a smooth matt veneer sometimes interrupted by black areas around the ostioles; interior of ectostroma rarely brittle refractive, normally corky, vinaceous or dark at sight, sometimes showing vinaceous particles on microscopic examination, sometimes not. Entostroma slight, dull brown to black. Perithecia one to many per stroma, spaced well apart or adjacent, evident to base or only at the vertices, globose to ovate,  $300-600 \times 400-700\mu$ ; ostioles umbilicate, sometimes raised or even papillate. Asci cylindric,  $100-190 \times 4-8\mu$ ; stipes  $30-100\mu$ . Spores gibbous, navicular or crescentic, with narrow ends, dark brown,  $3.5-7.5 \times 7.5-16.5\mu$ , ave.  $5.3 \times 11.2\mu$ .

*Material examined:*

Martin 906; Mazatlán, Sinaloa, Mexico, (1961). Martin 974, 993, 1512, 1526; San Blás, Nayarit, Mexico, (1961, 1962). Martin 1107; Columbia, Mo., U.S.A., (1962). Martin 1151, 1156; Lake Ozark, Mo., U.S.A., (1962). Martin 1806 ex Carroll 576; Rivercrest, Austin, Texas, U.S.A., (1963); Martin 1824; ex Kramer, Allen Co., Kansas, U.S.A., (1963). Rick 28; Sao Leopoldo, Brazil, (1904), (NYBG). Rogers 1600; on *Artocarpus incisus*,

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PLATE II Variation in Stromal colour. All  $\times 1$ ; except 16, 17, 19  $\times 0.3$

- 1-4. *Hypoxyton rubiginosum*
  1. typical aplanopulvinate
  2. young stage
  3. mummularioid, aplanate
  4. aplanate with scattered perithecia
5. *Hypoxyton sphaeriosporum*
6. *Hypoxyton rubiginosum* forma *trichocladi*
7. *Hypoxyton ferrugineum*
8. *Hypoxyton vogesiaceum*
9. *Hypoxyton denudatum* (Annulata group) for comparison
10. *Hypoxyton fuscum*
- 11, 12. *Hypoxyton bicolor*, yellow and reddish purple forms
- 13, 14. *Hypoxyton crocopleum*, pulvinate and effuse forms
15. *Hypoxyton hypomiltum*, young
16. *Hypoxyton murcidum*, yellow initial stage
17. *Hypoxyton croceum*, salmon pink conidial growth
18. *Hypoxyton aureostroma*
19. *Hypoxyton daldiniiforme*







- Marshall islands, (1946), (NYBG). Thaxter 6617; Palm Beach, Fla., U.S.A., (1897-1898), (NYBG).
- sub *Hypoxylon rubiginosum* v. *gregaria*  
Morgan 1097; Ohio, (details incomplete), (NYBG),
- sub *Hypoxylon vinoso-purpureum*  
Langlois 2157; St. Martinsville, La. U.S.A. (1889), (NYBG).
- sub *Rosellinia calami*  
Merrill, Flor. Philippines 8481; on *Bambusa* sp., Luzon, Manila, Philippines, (1912), (NYBG).
- sub *Rosellinia melaleuca*  
Earle & Murrill 234; San Antonio de los Baños, Havana province, Cuba, (1905), (NYBG).  
Seaver in NYBG West Indian Explor. 798; St. Thomas, Puerto Rico, (1923), (NYBG).  
Smith, Central Amer. Fungi 11; Ometepe, Nicaragua, (1893), (NYBG), (stated as type).
- sub *Rosellinia mutans*  
Webber; Lincoln. Neb., U.S.A., (1889), (NYBG).

*Cultural characters:* (Plate IV: 6; Plate V: 3)

Colonies felty to velvety or cottony, with fine or coarse texture, without mycelial aggregates; margin not distinct, hyphae dispersed or lying together. Aerial mycelium pure or dull white. Conidia appear by a week, or when old. Stain red brown or amber. Growth rate moderate, 2·6—3·2 mm./day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of marginal hyphae = 2·3 $\mu$ . Secondary mycelium loose or ropy, 1·5—5·6 $\mu$  diam.

*Conidiophores and conidia:* (Plate VII: 1—2; Plate X: 9).

This species has a *Graphium* type coremium which is frequently seen in connection or association with stromata. These coremia are 100—210 x 200—800 $\mu$ , ropy, separate or joined, unbranched or rarely bifurcate, aristate, dull brown, and fertile over the apices only. Coremia have not been observed in culture.

Conidiophores produced in culture are somewhat similar to those of *H. investiens*, usually smooth walled and colourless but sometimes warted and tinted dull brown, 140—840 x 1·8—2·7 $\mu$ . Axes are branched dichotomously or ternately to the first degree or indefinitely, over the upper parts or apices only; otherwise growth may be sympodial. Fertile branches are usually smooth but sometimes irregular in outline, lying free or in trident formation, with unmodified apices, 13—105 x 1·8—2·5 $\mu$ . Conidia in fascicles off the sides of the hyphae, pleurocrogenous or acrogenous, sessile, clavate with narrow bases, white or pink, 1·2—2·3 x 3·2—4·7 $\mu$ , ave. 1·8 x 3·9 $\mu$ .

This species is intermediate between three groups of *Hypoxylon*: similar to *Entoleuca* in having separate perithecia and occasional papillate ostioles, similar to *Papillata* in the nature of coremia and conidiophores, and similar to *Euhypoxylon* in general stromal characters. These similarities are noticeable in other members of the *Oodes* and *Fragiforme* series but are not present together as in this species.

## 2. *Hypoxylon croceum* Miller (Plate II: 17)

Miller J. H. *Mycologia* **25**, 323, (1933); *Monog. Univ. Puerto Rico* **B 2**, 199, (1934); *World Species of Hypoxylon*, 55, (1961).

Stromata aplanate, crustose, sometimes uniperitheciate and globose, superficial on bark and decorticated wood,  $0.6\text{--}7.0 \times 1.1\text{--}21 \times 0.7\text{--}1.5$  mm, often seen in association with salmon pink conidial masses, but no definite coremia. Ectostroma reddish brown to brown as in *H. investiens*, similarly often varying in colour from one part to another and becoming dull black in age. Interior of ectostroma is reddish brown, while the entostroma, below the perithecia, is dark brown to black, usually contrasting sharply. Perithecia evident to base or only vaguely evident above the stroma level, globose to oval,  $350\text{--}650 \times 400\text{--}700\mu$ ; ostioles raised but not distinct or invisible and at stroma level, or clearly umbilicate. Asci cylindric,  $82\text{--}173 \times 4\text{--}7\mu$ ; stipes  $33\text{--}90\mu$ . Spores very variable in shape, equilateral to navicular, ranging from subglobose to narrowly elliptic, often within the same sample; elliptic spores usually with one end blunt and the other tapering; medium brown to dark brown or greyish brown,  $3.0\text{--}7.0 \times 7.5\text{--}14.5\mu$ , ave.  $4.6 \times 9.9\mu$ .

Hosts: *Lycium campanulatum*, *Quercus* spp., *Virgilia oroboides*.

### Material examined:

Miller 1815, 2198, 2199; on *Liriodendron tulipifera*, Barron Playhouse, Rabun, Ga., U.S.A., (1929 & 1932) (Mill). Martin 418; Fish River Valley, nr. Grahamstown, E. Cape South Africa, (1958). Martin 561; Nature's Valley, Knysna District, Western Cape, South Africa, (1959). Martin 1149, 1151, 1156, 1171, 1178; Lake Ozark, Mo., U.S.A., (1962).

### Cultural characters: (Plate IV: 1, 5; Plate VI: 1)

Colonies canescent to thin appressed velvet; smooth with dull white subhyaline aerial mycelium. Margin entire, compact to slightly effuse, not distinct. After 4 days conidia develop profusely over the entire colony, which then turns salmon pink in colour. Stain absent or diffuse pale willow green. Growth on other media is similar except for Czapek where it is much less luxuriant. Growth normally fast, occasionally moderate,  $2.5\text{--}5.3$  mm. per day at  $25^{\circ}\text{C}$ .

### Microscopic characters:

Primary mycelium undiagnostic; marginal hyphae with a maximum diameter of  $2.3\mu$ . No secondary mycelium.

### Conidiophores and conidia: (Fig. II: 12)

Conidiophores usually distinct from the vegetative mycelium by the whorled or verticillate nature of the ultimate branches which are sometimes also rather highly refractive when viewed dry under a coverslip;  $120\text{--}560 \times 1.2\text{--}3.7\mu$ , branched to the first degree to indefinitely over the entire length of the main axes or over their upper halves only; branching rarely dichotomous, usually



verticillate with 3—6 branches per verticil. Fertile branches lying freely, occasionally somewhat geniculate (cf *Nodulisporium*) with elliptic, blunt or slightly swollen apices,  $6.2\text{--}31 \times 1.2\text{--}1.9\mu$ . Conidia in apical clusters, in short pleurocrogenous spikes, or in groups off the hyphae; sessile or on slender sterigmata, elliptic equilateral or narrow clavate, with bluntly pointed ends, ranging from salmon pink to red brown or brick orange collectively,  $1.2\text{--}2.3 \times 4.2\text{--}6.0\mu$ , ave.  $1.6 \times 4.6\mu$ .

### 3. *Hypoxylon riograndense* Rehm.

Rick J. Brotéria Ser Bot **25**, 33 (1931). Theissen F. Ann. Mycol. **7**, 154, (1909)

Stromata crustose, orbicular, linear, or irregularly aplanopulvinate, superficial,  $1.1\text{--}24 \times 2.8\text{--}10 \times 60.4\text{--}1.7$  mm. Colour characteristically purple-red, sometimes violaceous to maroon, turning black with age. Ectostroma smooth; interior not clearly differentiated; granular particles normally not conspicuous but sometimes dull red. Entostroma slight, dull brown to black, corky. Perithecia one to several per stroma, with evident vertices or completely immersed, loosely coalesced to adjacent, sometimes close-crowded, ovate,  $200\text{--}500 \times 200\text{--}700\mu$ ; ostioles not visible or normally umbilicate. Asci cylindric,  $60\text{--}110 \times 4\text{--}6\mu$ ; stipes  $9\text{--}60\mu$ . Spores equilateral, amber to pale brown, subhyaline to opaque,  $3.0\text{--}7.0 \times 5.0\text{--}15.0\mu$ , ave.  $4.1 \times 8.2\mu$ .

*South African hosts: Wood unidentified.*

*Material examined:*

sub *Hypoxylon jecorinum*

Kauffmann; Hot Springs, North Carolina (1924), (AA).

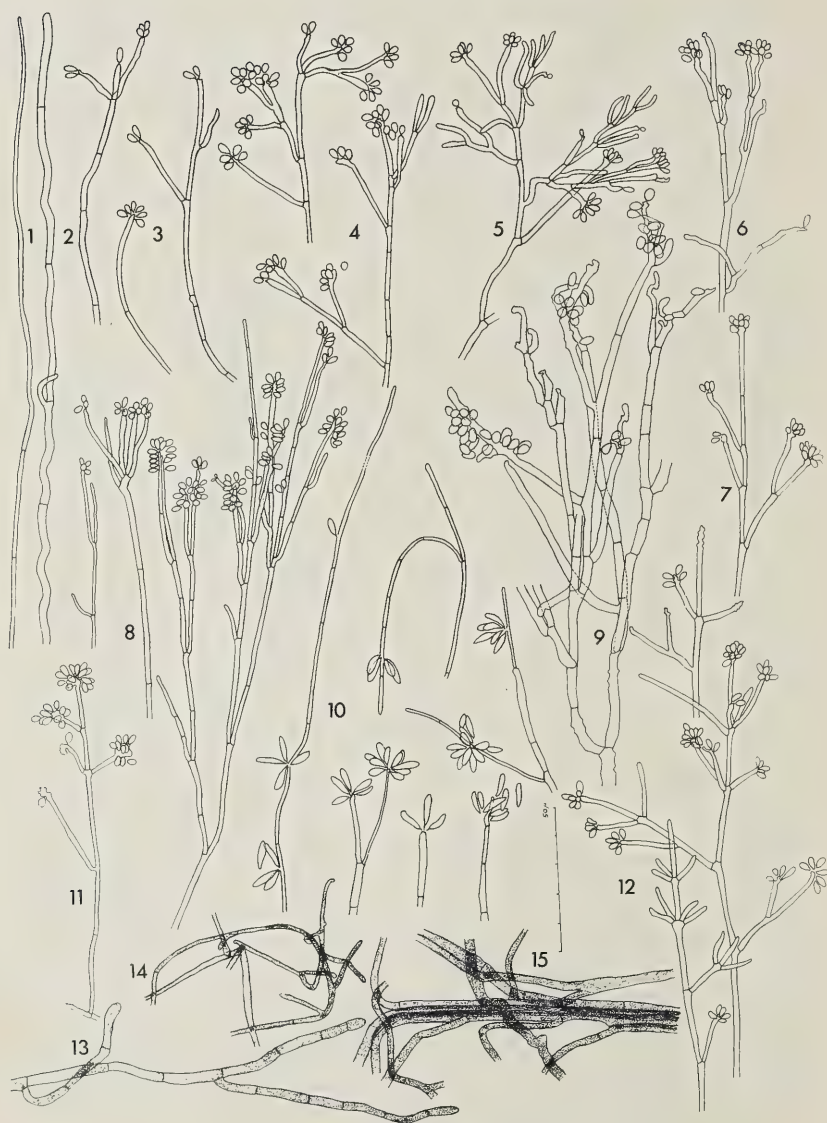
sub *Hypoxylon riograndense*

Martin 534; Highlands Mtn., Albany District, E. Cape, South Africa, (1959). Martin 977, 978, 987; San Blàs, Nayarit, Mexico, (1961). Rick; Brazil, (1907), (AA).

PLATE III Variation in Colony colour. Cultures on malt, 2 weeks old at  $25^{\circ}\text{C}$ , except where stated.

- 1—2. *Hypoxylon rubiginosum*
3. *Hypoxylon sphaeriosporum*
4. *Hypoxylon plumbinum*, on Czapek
5. *Hypoxylon vogesiaceum*
- 6, 7. *Hypoxylon fuscum*
- 8—10. *Hypoxylon bicolor*
- 11, 12. *Hypoxylon novemexicanum*
13. *Hypoxylon croceoplum*
- 14—16. *Hypoxylon aureostroma*
- 17—20. *Hypoxylon rubiginosum* showing extremes
- 17—18 On malt
- 19—20 On Czapek
21. *Hypoxylon vogesiaceum*
22. *Hypoxylon plumbinum*, on Czapek
23. *Hypoxylon murcidum*
24. *Hypoxylon rubiginosum* forma *trichocladi*







**Cultural characters** (Plate V: 9; Plate VI: 2)

Colonies first appressed later felty with a coarse surface, later becoming denser and velvety, with dull white to olive brown aerial mycelium. Margin entire, not distinct; hyphae lying close together. Conidia appearing in granulate masses, immediately or with age; white to very pale grey. Stain at first orange yellow, orange red or roseate, turning red-brown with age. Appearance on other media similar to that on malt, but less luxuriant, and with greenish brown stain on maize, and with grey aerial mycelium and deep ochre stain on Czapek. Growth rate moderate to fast; 3·6—7·6 mm/day at 25°C.

**Microscopic characters:** (Fig. II: 2)

Primary mycelium unspecialized, with maximum diameter of 2·7 $\mu$ . Secondary mycelium uniform, loose or ropy, 1·4—3·8 $\mu$  diam.

**Conidiophores and conidia:** (Plate VIII: 4)

Conidiophores distinct from the vegetative mycelium by the verticillate branching and shorter ultimate branches; 50—300  $\times$  2·5—2·8 $\mu$ , sometimes dichotomously but usually ternately or multi-branched to the second degree. Axes of conidiophores sometimes tinted dull brown. Fertile branches 7·5—35  $\times$  1·2—1·5 $\mu$ , straight or somewhat curved, in trident formation, normally with unmodified apices. Conidia borne in apical clusters of 3—8, sessile, clavate to oval-elliptic, with narrow bases, white collectively, 1·2—2·3  $\times$  2·9—5·0 $\mu$ , ave. 1·6  $\times$  3·7 $\mu$ .

**4. *Hypoxylon murcidum* Berk. & Br.** (Plate I: 3, 7; Plate II: 16)

Berkeley M. J. & C. E. Broome Jour. Linn. Soc. **14**, 123, (1875).

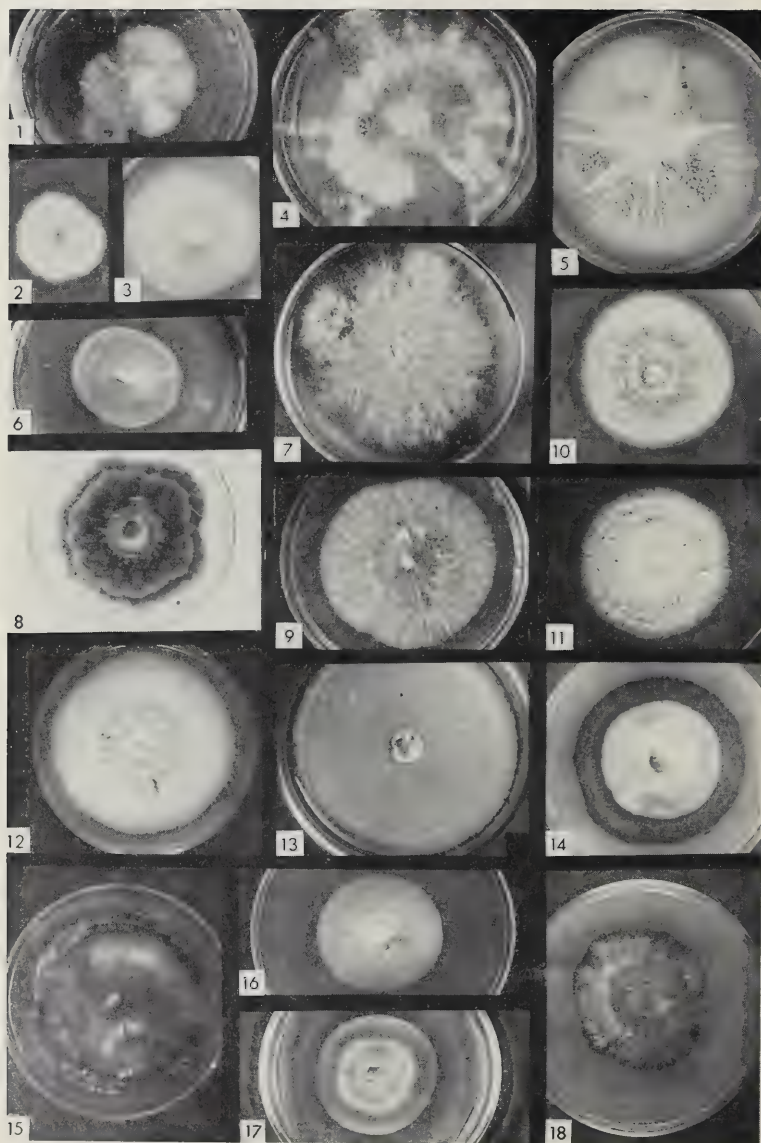
Stromata aplanate or aplanopulvinate, consisting of a matrix in which the perithecia develop independently, so that at maturity they may be separated or

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FIG. II. Microscopic characters.

- 1—2 Variation in marginal hyphae
  - 1. *Hypoxylon bicolor*
  - 2. *Hypoxylon riograndense*
- 3—12 Conidiophores and conidia
  - 3. *Hypoxylon rubiginosum*, *Sporothrix* types I—II
  - 4. *Hypoxylon vogesiacum*
  - 5. *Hypoxylon croceopileum*
  - 6. *Hypoxylon daldiniforme*
  - 7. *Hypoxylon fuscum*
  - 8. *Hypoxylon plumbinum*
  - 9. *Hypoxylon viridicolor*
  - 10. *Hypoxylon murcidum*, *Sporothrix* type I
  - 11. *Hypoxylon novemexicanum*, *Sporothrix* type III
  - 12. *Hypoxylon croceum*, *Sporothrix* type IV

} *Sporothrix* type II
- 13—15 Secondary mycelium
  - 13. *Hypoxylon vogesiacum*
  - 14. *Hypoxylon rubiginosum*
  - 15. *Hypoxylon daldiniforme*



coalescent. The globose outline of the mature perithecia, indistinct or minutely papillate ostioles, brilliant yellow initial stage and deep purple surface colour at maturity serve to distinguish this species from *H. rubiginosum* where it was placed by Miller (1961), and from other very similar species—*H. occidentale*, *H. dieckmanni* & *H. riograndense*. Ectostroma refractive, breaking into red vinaceous particles; entostroma slight, reddish black. Perithecia evident to base or only vaguely evident, globose to ovate,  $250\text{--}350 \times 250\text{--}400\mu$ . Asci cylindric,  $105\text{--}160 \times 6\mu$ ; stipes  $35\text{--}70\mu$ . Spores elliptic; equilateral navicular, or crescentic, amber to dark brown,  $4.5\text{--}7.0 \times 8.5\text{--}15.0\mu$ , ave.  $5.3 \times 11.7\mu$ .

*South African hosts: Olea capensis.*

*Material examined:*

sub *Hypoxylon glomeratum*

Johnston 986, Fajardo, Puerto Rico, (1913), (NYBG)

sub *Hypoxylon murcidum*

Martin 470, 481, 1044, 1053; Nature's Valley, Knysna District, Western Cape, South Africa. Twaitte 1083; Ceylon (details incomplete), (Mill.).

*Cultural characters* (Plate III: 23)

Colonies at first submersed and hyaline, later developing sparse appressed white subhyaline aerial mycelium and finally after 2 weeks a thin aerial mat gradually becoming dense velvety with age. Surface fine and smooth, becoming granulate after development of pale grey conidia. Colour of mature colonies mouse grey. Margin distinct, 3–6 mm., hyphae close together. Stain at first roseate to brandy colour, later deepening and finally turning dull grey black. Appearance on other media similar but restricted on Czapek: mycelium white, tinted pale red, stain deep red and spreading beyond the colony border. Growth moderate 2.9 mm/day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $2.6\mu$ . Secondary mycelium reticulate,  $1.9\text{--}2.9\mu$  diam.

*Conidiophores and conidia:*

Conidiophores little differentiated from the vegetative mycelium,  $75\text{--}190 \times 1.2\text{--}2.5\mu$ , unbranched or branched once dichotomously, very lax, with conidia

PLATE IV Young plate cultures. 1–3, 6, 9, 10–11, 16–17; 7 days old  
4–5, 7–8, 12–15, 18; 14 days old  
On malt agar at 25°C.

- |                                      |                                     |
|--------------------------------------|-------------------------------------|
| 1. <i>Hypoxylon croceum</i>          | 11. <i>Hypoxylon fuscum</i>         |
| 2, 3, 4. <i>Hypoxylon plumbinum</i>  | 12. <i>Hypoxylon sphaeriosporum</i> |
| 5. <i>Hypoxylon croceum</i>          | 13. <i>Hypoxylon fuscum</i>         |
| 6. <i>Hypoxylon oodes</i>            | 14. <i>Hypoxylon viridicolor</i>    |
| 7. <i>Hypoxylon dieckmanni</i>       | 15. <i>Hypoxylon hypomilum</i>      |
| 8. <i>Hypoxylon novemexicanum</i>    | 16. <i>Hypoxylon bicolor</i>        |
| 9. <i>Hypoxylon rubrostromaticum</i> | 17. <i>Hypoxylon croceopeplum</i>   |
| 10. <i>Hypoxylon ferrugineum</i>     | 18. <i>Hypoxylon daldiniiforme</i>  |

in fascicles or in small apical clusters. Fertile branches often distinctly narrower distally,  $25-53 \times 0.7-2.3 \mu$ , with unspecialized apices. Conidia borne on slender sterigmata, with narrow rounded or acute apices, linear, pale grey en masse,  $1.7-2.6 \times 6.6-17.1 \mu$ , ave.  $2.0 \times 8.7 \mu$ .

This species can be clearly distinguished from *H. rubiginosum* on account of the ascospore characters and occasional papillate ostioles. The cultural characters are also quite distinct. The conidia are similar to those of *H. dieckmanni* in their extreme length.

#### 5. *Hypoxylon aureostroma* Martin, sp. nov. (Plate II: 18)

Stromata cum paucis peritheciis, fere pulvinata, aurea; ab *Hypoxylon haematostroma* peritheciis globosis differtur; sporae fuscae,  $4.5-8.5 \times 12.5-25.5 \mu$ , medius  $7.0 \times 15.5 \mu$ .

Stromata pulvinate, glomeruliform, or aplanopulvinate,  $1.5-5.0 \times 1.8-8.0 \times 0.8-1.7$  mm. Initial layer orange-yellow, surface of mature stroma yellow orange or yellow ochre. Ectostroma corky, orange red or orange yellow at sight, yielding yellow or orange particles in microscopic preparations; entostroma well-developed, dull brown to black. Perithecia evident to base or only at the vertices, globose to ovate, spaced well apart or adjacent,  $350-800 \times 450-1000 \mu$ ; ostioles umbilicate and fairly conspicuous. Asci cylindric or clavate,  $135-180 \times 8-10.5 \mu$ ; stipes  $40-75 \mu$ . Spores elliptic, equilateral, navicular or crescentic with short linear germ slits, medium to dark brown,  $4.5-8.5 \times 12.5-25.5 \mu$ , ave.  $7.0 \times 15.5 \mu$ .

##### Material examined:

sub *Hypoxylon aureostroma*

Martin 268; on *Acacia karoo*, near Alexandria, Eastern Cape, South Africa, (1958).

sub *Hypoxylon rubrostromaticum*

Thaxter, in Farlow 6880, in Miller 4648; St. Ann's Valley, Port of Spain, Trinidad, (1912-1913), (Mill.).

##### Cultural characters (Plate III: 14-16; Plate VI: 4)

Colonies velvety, forming a very dense smooth mat up to 2 mm. high; aerial mycelium at first white then tinted pale yellow, saffron or buff towards the centre and reddish towards the outside. After 21 days reddish brown drops are exuded over the centre. Margin not distinct; hyphae lying together. Conidia very infrequent, only appearing with age in pale pink aggregates. Stain light roseate to deep red or red-brown, uniformly diffused. Appearance on other media similar but somewhat less luxuriant; submersed on Czapek then developing radiating furrows with age. Growth rate moderate, 3.2 mm/day at 25°C.

##### Microscopic characters:

Primary mycelium unspecialized; maximum diameter of marginal hyphae =  $1.5 \mu$ . Secondary mycelium loose,  $1.5-4.3 \mu$  in diameter.



*Conidiophores and conidia:* (See Martin, 1967, p. 228, fig. 4)

Conidiophores with distinct sympodial branching, only at present seen in 2 other species (*H. subchlorinum*, *H. oodes*);  $100\text{--}200 \times 1.5\mu$ . Branching is dichotomous extending to the second degree, over the length of the main axes. Fertile branches very short,  $2\text{--}22 \times 1.0\text{--}1.2\mu$  with unmodified apices. Conidia acrogenous, sessile, clavate with narrow bases, white to pale pink,  $1.4\text{--}2.2 \times 3.4\text{--}4.4\mu$ , ave.  $2.4\text{--}4.1\mu$ .

This species is possible to confuse with *H. haematostroma* but is sharply distinct on cultural grounds, apart from minor stromal differences.

The remaining species in this group, *H. notatum*, was not available for culture.

### The Rubiginosum Series

*Hypoxylon rubiginosum*, perhaps the most common species in the genus, has acquired an enormous number of synonyms which are listed fully by Miller, (1961, pp. 26-28). Miller's conception of *H. rubiginosum* is clearly that of a number of forms linked by so many intergrades that recognition of them as separate entities is impossible. Theissen (1909, p. 147) suggested more flexibly that as many as 9 species or varieties might be included under the same term. The writer considers that at least 5 species are clearly separable from *H. rubiginosum* on a combination of stromal and cultural features. These include *H. plumbinum* Martin, material of which was sent to the late Dr. Miller and classified as a non-pigmented variant of *H. rubiginosum*, *H. sphaeriosporum* Martin, and several species considered as synonyms in his monograph: *H. murcidum* B. & Br., *H. albstigmatosum* Speg., and *H. subchlorinum* Ell. & Calkins. The last two are described in the Hypomiltum series.

The stromata can be placed in order of increasing degree of colour and internal differentiation, as follows:

#### 6. *Hypoxylon plumbinum* Martin nov. sp. (Fig. I: 6)

Stromata elliptica vel inequalis vel fusco brunnea; ab *Hypoxylon rubiginosum* differtur pigmento sporis majorisque.

Stromata oval-elliptic or irregular in form, thin, aplanate to aplanopulvinate, superficial or erumpent through bark,  $0.5\text{--}8.0 \times 0.8\text{--}2.8 \times 0.4\text{--}1.5$  mm. Surface of stroma rarely smooth, usually somewhat wrinkled; ectostroma often bearing superficial granular dark grey to black particles visible on microscopic section; colour variable, from grey to grey brown at maturity to black with age, never purple. Interior of stroma not clearly differentiated, corky, grey to brown without coloured particles; outer portion sometimes gelatinous when immature, and tinted yellow when seen in longitudinal section; entostroma beneath the perithecia rather slight in quantity. Perithecia often close crowded, in superficial stromata evident in outline with prominent conic obtuse vertices, in immersed



stromata usually not evident; globose or oval,  $250-600 \times 300-700\mu$ . Ostioles usually not clearly visible, more rarely umbilicate. Asci cylindric usually long stipitate,  $95-230 \times 5-9\mu$ . Spores elliptic, rarely equilateral, usually gibbous, navicular or somewhat crescentic, dark brown or black  $4.5-8.5 \times 8.0-18.0\mu$ , ave.  $5.9 \times 12.7\mu$ .

*South African hosts:*

*Cassine croceum*, *Olea capensis*, *Passerina falcifolia*, *Populus canadensis*, *Tarchonanthus camphoratus*, *Vepris lanceolata*.

*Material examined:*

sub *Hypoxylon ianthinum*

Macoun 303 in Cooke 5018, 5018 A; Bellville, Ont., Canada, (1882), (NYBG).

sub *Hypoxylon plumbinum*

Martin 17, 92, 106, 166, 376, 407, 493, 494, 498, 515, 518, 558, 560, 1024, 1036, 1037, 1040; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959, 1962). Martin 193, 220, 547, Hogsback, nr. Alice, Eastern Cape, South Africa, (1958, 1959). Martin 277; Alexandria forest, Eastern Cape, South Africa, (1958). Martin 719; Klamath river, Northern California, U.S.A., (1961). Martin 973, San Blas, Nayarit, Mexico, (1961).

*Cultural characters* (Plate III: 4, 22; Plate IV: 2-4)

Colonies canescent, white subhyaline and mainly submersed or thin velvety, smooth, with opaque white aerial mycelium. Margin not distinct, or forming a broad colourless zone 2-18 mms. wide; entire, with the peripheral hyphae lying together. Conidia develop as a thin fawn-brown layer at a variable time after inoculation, in some strains by 7 days, in others only with extreme age, after 4-8 months. Stain rarely absent, typically violaceous to rose or pink, sometimes dull orange brown. On other media the margin tends to be distinct, and the stain is more intense, on Czapek often brilliant roseate orange and extending well beyond the margin of the colony. Growth slow,  $0.9-2.0$  mm per day at  $25^{\circ}\text{C}$ .

*Microscopic characters* (Fig. II: 8):

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $2.7\mu$ . Secondary mycelium absent.

*Conidiophores and conidia:*

Conidiophores scarcely distinct from the vegetative mycelium or recognizable as indeterminate mycelial systems,  $24-690 \times 0.7-2.1\mu$  unbranched, dichotomously branched or rarely ternately and quadrately branched to the first or second degree or indefinitely, usually over the upper halves of the main axes. Fertile hyphae lying freely or less commonly in trident formation,  $9-83 \times 0.6-2.0\mu$ ; unspecialized, with apices not swollen. Conidia strictly apical or acropleurogenous, in spicate clusters, sessile, broadly oval to oval-elliptic or clavate, with narrow bases, fawn brown collectively,  $1.4-2.9 \times 2.0-5.1\mu$ , ave.  $2.1 \times 3.4\mu$ .

This species is closely related to *Hypoxylon macrosporum* Karsten (1873)

which has been wrongly attributed by Miller (1961) to *H. mammatum* (Wahl) Miller. Type material of *H. macrosporum* (Karsten 775; on *Salix*, Karelia, Sweden, 1861) obtained by the writer from the herbarium at the University of Helsinki showed that it resembled *H. plumbinum* in all major respects except for the spores, which were large, gibbous, medium to dark brown, translucent to opaque,  $7.5-12.0 \times 22.5-32.5 \mu$ , ave.  $10.3 \times 27.3 \mu$ . Material of *H. plumbinum* sent to the late J. H. Miller was classified as one of the many variants of *H. rubiginosum* recognized by him.

### 7. *Hypoxylon ferrugineum* Otth. (Plate I: 9, Plate II: 7)

Cited in Miller J. H. World Species of *Hypoxylon* 32, (1961)

Stromata aplanate, characteristically erumpent, with the surface at bark level,  $4.5-9.3 \times 8.1-30 \times 0.8-0.9$  mm. Surface of stroma uneven, olive or yellow green to ferrugineous. Interior of stroma not clearly differentiated. Ectostroma corky, without demonstrable coloured particles; entostroma well developed but not massive, dull brown to black. Perithecia evident at the vertices, or sometimes immersed, ovate,  $400-500 \times 600-800 \mu$ ; ostioles usually clearly evident, wide umbilicate with white periphysate mouths. Asci cylindric,  $120-160 \times 5-7 \mu$ ; stipes  $66-100 \mu$ . Spores oval, navicular to crescentic, light brown,  $3.5-7.5 \times 7.5-13.0 \mu$ , ave.  $5.8 \times 10.8 \mu$ .

*South African Hosts*: *Olea capensis*; apparently host-specific.

*Material examined*:

Martin 121, 327, 385, 386, 417, 504, 1000, 1015, 1033; Nature's Valley, Western Cape, South Africa, (1958, 1959, 1962).

### *Cultural characters* (Plate IV: 10; Plate V: 3)

Colonies velvet felty, with coarse surface; aerial mycelium dull white, tinted olive green in parts. Margin distinct, compact, submersed, 2–9 mm broad. Conidia produced in pulvinate masses over surface of the colony in age, pale green to brown. Stain olive green or paler, deepening to dull brown. Appearance on other media similar, but less luxuriant on Czapek. Growth rate moderate, 3.4 mm/day at 25°C.

### *Microscopic characters*:

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $2.2 \mu$ . Secondary mycelium reticulate,  $1.9-3.6 \mu$  in diameter.

### *Conidiophores and conidia*:

Conidiophores rather short,  $100-200 \mu$  long, with axes  $1.2-1.5 \mu$  in diameter, compactly multibranched dichotomously or ternately over the upper parts of the main axes. Fertile branches lying freely,  $15-75 \times 1.2-1.5 \mu$ , with

unspecialized heads. Conidia acrogenous, sessile, short clavate with narrow bases, olive green to brown, small in relation to those of other species,  $1.4-2.3 \times 2.0-4.0\mu$ , ave.  $1.9 \times 2.7\mu$ . These are the smallest conidia in the entire species group.

#### 8. *Hypoxydon dieckmanni* Theiss. (Plate I: 3)

Miller J. H. World Species of *Hypoxydon* 33, (1961)

Rick J. Brotéria Ser. Bot. 25, (1931). Theissen F. Annales Mycol. 6, 346 (1908); Ibid 7, 153, (1909).

Stromata aplanate or aplanopulvinate, crustose, linear or irregular in shape,  $2.2-18 \times 3.5-89 \times 0.9-1.3\mu$ . Colour characteristically deep purple-red at maturity. Ectostroma smooth, breaking into dull red vinaceous particles. Entostroma slight, dull brown to black, corky. Perithecia several per stroma, in palisade formation, evident at vertices or vaguely evident,  $400-500 \times 500-600\mu$ ; ostioles at stroma level and not visible. Asci cylindric  $100-120 \times 4.5\mu$ ; stipes  $42-54\mu$ . Spores equilateral oval, rather small, with broad rounded ends and sometimes nearly parallel sides, amber, pale or dark brown,  $3.0-4.5 \times 6.5-11.5\mu$ , ave.  $3.9 \times 8.3\mu$ .

#### Material examined:

##### sub *Hypoxydon dieckmanni*

Kevorkian 15 = Miller 2344; Soledad, Cuba, (1935), (Mill.) Martin 1097, 1098; Columbia, Mo., U.S.A., (1962). Martin 1169, 1177; Lake Ozark, Mo., U.S.A., (1962). Rick, Brazil, (1908?), (Mill.). Rogers 1671; Marshall Islands, (1946), (NYBG).

##### sub *Hypoxydon investiens*

Brace 9629; New Providence, Bahamas, (1919), (NYBG).

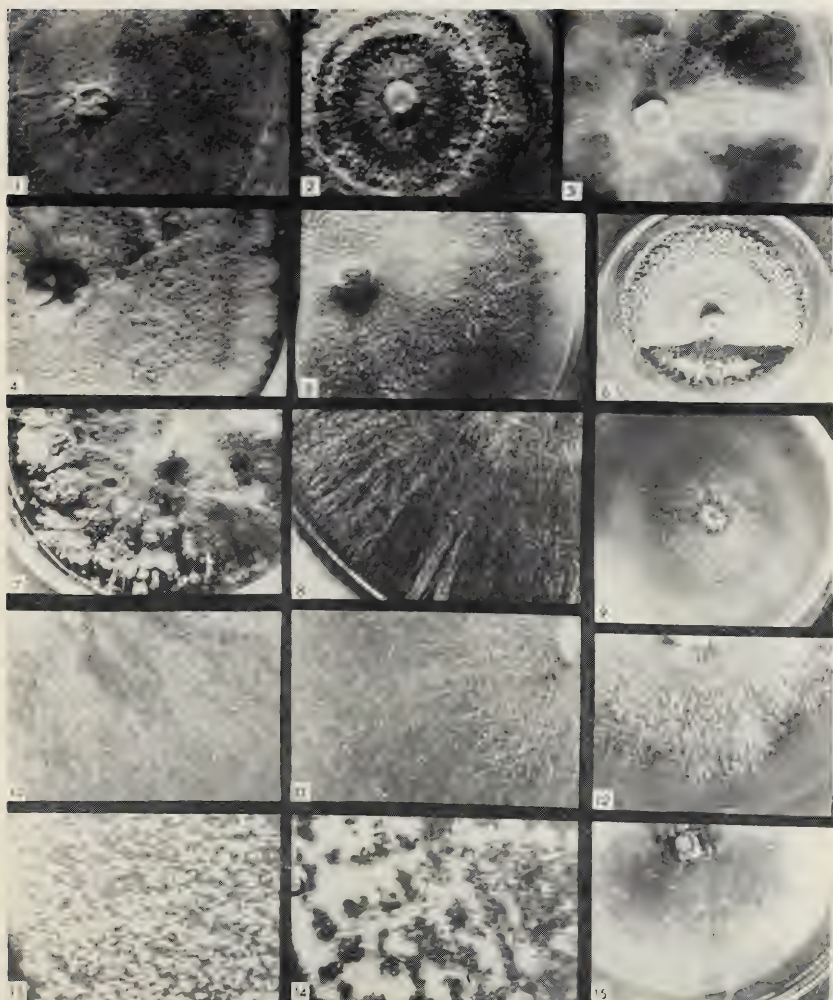
#### Cultural characters (Plate IV: 7; Plate V: 12)

Colonies at first submersed and hyaline, later developing canescent, felty or cottony, coarse dull white aerial mycelium spreading freely over the surface of

#### PLATE V Details of colony surface malt; plates, 21 days at 25°C when old.

- 1, 2. *Hypoxydon bicolor*: fine and coarse texture
3. *Hypoxydon oodes*: fine texture
4. *Hypoxydon howeianum*: mycelial aggregates of secondary mycelium dispersed throughout; inoculum pleomorphic
5. *Hypoxydon subchlorinum*: mycelial aggregates as above but smaller and marginal in distribution
6. *Hypoxydon rubiginosum*: mycelial aggregates of mostly primary mycelium
7. *Hypoxydon fragiforme*: coarse interior, conspicuous marginal conidial areas
8. *Hypoxydon crocopeplum*: conidia along linear strands of mycelium
9. *Hypoxydon riograndense*:
10. *Hypoxydon fuscum*:
11. *Hypoxydon rubrostromaticum*:
12. *Hypoxydon dieckmanni*:
13. *Hypoxydon albostigmatosum*: immediate and profuse conidial formation
14. *Hypoxydon haematostroma*: colony on blotting-paper showing dark mycelial aggregates with conidiophores
15. *Hypoxydon sclerophaeum*: colony with straggling surface, dark mycelial aggregates towards exterior

the medium, and becoming dense velvety with age. Margin not distinct, hyphae lying close together. Conidia fawn brown, developing immediately. Stain dull buff brown. Growth rapid, 6·1 mm/day at 25°C.





*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $1.2\mu$ . Secondary mycelium rosy,  $2.5\text{--}4.7\mu$  diameter.

*Conidiophores and conidia* (Plate VIII: 1-3) See also Martin (1967), p. 228 fig. 6 sub *H. murcidum*.

Conidiophores sharply differentiated from the vegetative mycelium, often with broad main axes, sometimes warted,  $75\text{--}310 \times 1.2\text{--}3.5\mu$ ; rarely unbranched, usually branched in verticils to the first or second degree over the upper parts of the main axes, with 2—5 branches in each verticil. Fertile branches lying free or in trident formation,  $10\text{--}18 \times 1.2\text{--}2.5\mu$  with unmodified or slightly swollen apices. Conidia produced on slender sterigmata, normally acrogenous, rarely in fascicles off the sides of the hyphae, long pyriform, linear elliptic or almost cylindrical, with narrow rounded distal ends, fawn brown en masse,  $0.9\text{--}1.3 \times 3.7\text{--}5.3\mu$ , ave.  $1.2 \times 4.7\mu$ .

This species can be clearly distinguished from *H. rubiginosum* in culture on account of the ascospore characters and the characters of the imperfect stage.

### 9. *Hypoxylon rubiginosum* Pers. ex Fr. (Plate I: 3; Plate II: 1-4)

The following are the most relevant publications. For others see Miller (1961).

sub *Hypoxylon rubiginosum*

Dennis, R. W. G., British Cup fungi, 177, (1960). Ellis J. B. & B. M. Everhart N. Amer. Pyren., 645 (1892). Fries, E. M. Syst. Mycol., 340, (1823); Summa Veg. Scand., 384, (1849). Jacewski, A. L. Bull. Soc. Myc. de France 11, 118, (1895). Miller, J. H. Mycologia 20, 315, (1928); Trans. Brit. Mycol. Soc. 15, 144, (1930); Monog. Univ. Puerto Rico, B, 2, 203, (1934); Bothalia, 4, 258, (1942); World Species of *Hypoxylon*, 26, (1961). Theissen, F. Ann. Mycol. 7, 147, (1909).

sub *Sphaeria rubiginosa* Persoon

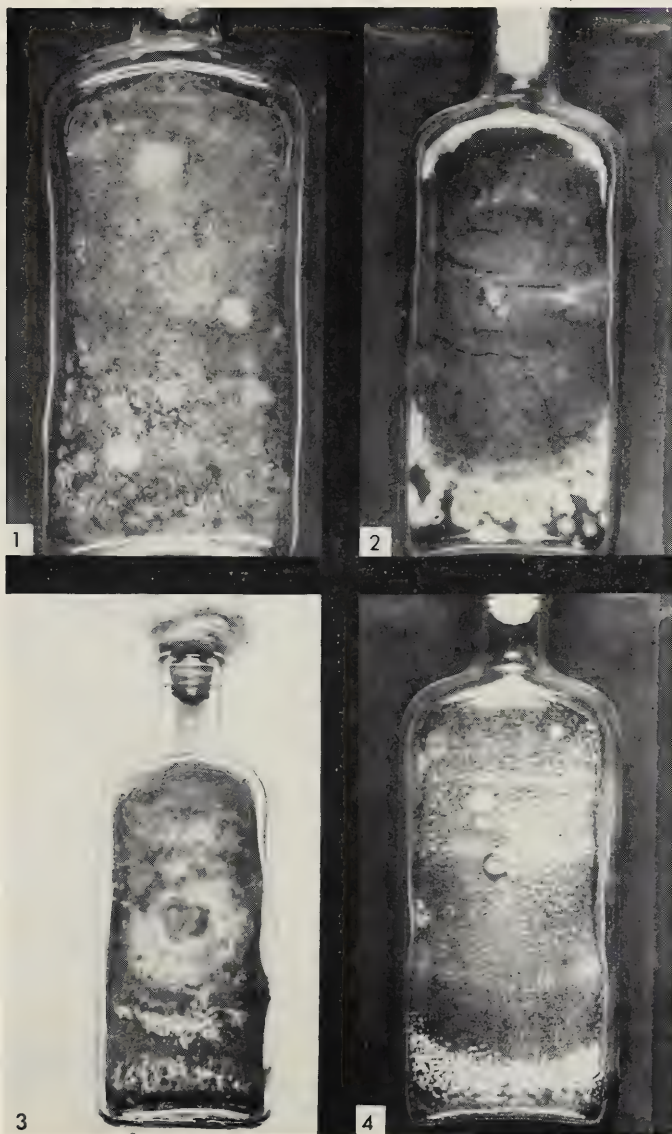
Persoon, C. H. Obs. Mycol. 69, (1796); Syn. Meth. Fung., 11, (1801-1808).

Stromata variable in form, pulvinate or effuse and indefinite in extent, normally superficial on bark or decorticated wood,  $1.5\text{--}6.5 \times 1.8\text{--}30 \times 0.4\text{--}1.8$  mms. Ectostroma normally bright purple superficially, sometimes reddish brown to ochraceous. Interior of ectostroma non-refractive, always pale red to purple, sometimes scarlet, in longitudinal section; entostroma usually rather slight in quantity, differentiated from the tissue above, dark red to red-brown. Ectostroma sometimes breaking up into dull vinaceous particles in squash mounts. Perithecia usually evident in outline above the general level of the stroma, sometimes developing singly and far apart from each other within a thin or extensive stromal matrix but usually fairly close crowded when the stromata are pulvinate; globose to ovate,  $150\text{--}550 \times 200\text{--}660\mu$ ; ostioles

PLATE VI Bottle cultures 2 months old, showing conidial development

1. *Hypoxylon croceum*
2. *Hypoxylon riograndense*
3. *Hypoxylon ferrugineum*
4. *Hypoxylon aureostroma*





umbilicate, usually distinct, with characteristic white periphysate mouths in pulvinate stromata. Asci cylindric,  $75-170 \times 5-8\mu$ ; stipes  $18-102\mu$ . Spores gibbous, navicular or slightly crescentic, light or medium brown and subhyaline, rarely dark brown and opaque,  $3.5-7.0 \times 8.0-14.0\mu$ , ave.  $5.4 \times 10.5\mu$ .

*South African Hosts:* Probably comprise a wide range, including *Acacia mollissima*, *Olea capensis*, *Populus canadensis*, *Scutia myrtina*, *Sideroxylon inerme*.

*Material examined:*

A wide range of material in the herbaria cited.

Martin 5, 6, 69, 86, 124, 148, 317, 318, 328, 339, 388, 420, 421, 437, 468, 474, 479, 485, 500, 501, 502, 505, 1005, 1007, 1020, 1192; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959, 1962). Martin 392, 580; Fernkloof, Grahamstown, E. Cape, South Africa, (1958, 1960). Martin 538, 564, 566; Highlands mtn., nr. Grahams-town, E. Cape, South Africa, (1959). Martin 541, 542, 545, 553; Hogsback, nr. Alice, E. Cape, South Africa, (1959). Martin 637, ex C. Booth (CMI), on *Albizia zygia*, Kori, Sierra Leone, (1961). Martin 641; ex Lowy, Baton Rouge, La., U.S.A., (1961). Martin 710, 727; Klamath National Forest, N. Calif., U.S.A. (1961). Martin 801, 802, 854; Arcata, N. Calif., U.S.A., (1961). Martin 903; ex Hennebert, Ontario, Canada, (1961). Martin 1077, 1078, 1101, 1102; Columbia, Mo., U.S.A. (1962). Martin 1115, 1121, 1148; Lake Ozark, Mo., U.S.A., (1962). Martin 1609; Stoneybrook, Rockland Co., N.Y., U.S.A. (1963). Martin 1703; Mt. Toby State Forest, Mass., U.S.A. (1963). Martin 1717; Savoy State Forest, Mass., U.S.A., (1963).

*Cultural characters* (Plate III: 1-2, 17-20; Plate V: 6)

Colonies velvety to velvet-felty, somewhat floccose when young, with raised central area. Surface characteristically fine, in contrast to *H. fuscum*, colour pink to saffron yellow, reddish or ochraceous, rarely dull white, with considerable variation in the same strains demonstrated by growth of monospore and multispore cultures. Normally colouration develops directly or soon after inoculation, especially in bottle culture, forming a large central blaze or halo round the centre, reaching maximum intensity after 14 days and then gradually fading. At maturity the outer part of the colony typically shows many small soft mycelial aggregates. Margin distinct, submersed, 3-13 mm wide; peripheral hyphae lying together. Conidia not produced in plate culture but evident in bottles after 4-8 weeks in various degrees of profusion, usually sparse and inconspicuous, orange brown. Stain variable, absent entirely or produced after 3 days, roseate orange, dull olive brown, or rarely olive green, diffusing up to but not beyond the margin and deepening with age. Growth on other media similar; that on Czapek tending to develop radiating furrows, accompanied by very intense hue of stain. Growth rate moderate,  $2-4-2.9$  mm/day at  $25^{\circ}\text{C}$ .

*Microscopic characters* (Fig. II: 3):

Primary mycelium undiagnostic, maximum diameter of the marginal hyphae  $=2.3\mu$ . Secondary mycelium reticulate, loosely or closely anastomosed, with frequent branching, hyphae  $1.8-3.7$  diameter.

*Conidiophores and conidia:*

Conidiophores only distinct from the vegetative mycelium by the shorter ultimate branches, variable in length,  $70-500 \times 1.2-3.1\mu$ , unbranched or branched up to the second degree over the terminal parts or upper halves of the main axes; branching usually dichotomous and rarely ternate, in contrast to *H. fuscum*; fertile branches lying freely, unspecialized,  $12-63 \times 1.4-2.5\mu$ . Conidia acrogenous in clusters of 4-6, sessile, pyriform to napiform or clavate,  $1.8-3.1 \times 3.7-5.6\mu$ , ave.  $2.3 \times 4.8\mu$ .

This species is separable only from *H. fuscum* and *H. vogesiacum* on a combination of characters, chiefly the ascospore colour and size, and the simple type of conidiophore.

**10. *Hypoxylon rubiginosum* forma *trichocladi* Martin. (Plate II: 6)**

Stromata crustose, aplanate effuse, rather thin,  $3-16 \times 5-6 \times 0.5-0.6$  mm, partly embedded in bark though still superficial. Surface of stroma deep purple, interior deep red, entostroma dark brown, well differentiated. Perithecia evident in outline, vertices flattened,  $200-250 \times 450-550\mu$ ; ostioles conspicuously umbilicate with tufts of white periphyses, asci cylindric, nearly sessile,  $90-125 \times 7-8\mu$ ; stipes  $15-35\mu$ . Spores oval-elliptic, equilateral, navicular or slightly concave, dark grey to black,  $4.5-7.5 \times 9.0-13.5\mu$  ave.  $6.2 \times 11.8\mu$ .

*South African Hosts: Trichocladus crinitus, Trichocladus ellipticus.*

*Material examined:*

Martin 373, 374, 467, 549; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959).

This might be regarded as a separate species were it not that *H. rubiginosum* material was observed on the same substrate showing gradations from the striking purple colour and crustose shape of this form to the normal. Material sent to the C.M.I. was identified as *H. haematostroma*, but it is distinct both on stromal and cultural grounds.

*Cultural characters* (Plate III: 24):

Colonies velvet-felty, dense and opaque, rarely subhyaline with smooth surface, dull white, sometimes tinted pale red. Saltants of much less luxuriant type frequently occur, suggesting genetic instability. Mycelial aggregates absent. Margin distinct, submersed, 2 mm. broad; peripheral hyphae compact. Stain red to red-black, characteristically irregular in formation, either in large semi-circular areas concentrically arranged around the colony centre, or in small flecks, or rarely diffuse and evenly spread. Growth slow, 1.4 mm/day at 25°C.

*Microscopic characters* (Fig. II: 14):

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $2.7\mu$ . Secondary mycelium branched, ropy,  $1.9-3.6\mu$  diam.

*Conidiophores and conidia:*

Sterile. This unfortunately makes final diagnosis rather arbitrary. On the whole this type shows the greatest general similarity is to *H. rubiginosum*, so it may be regarded as an unstable variant, whose expression in nature is favoured by growth on a particular host.

11. *Hypoxylon sphaeriosporum* Martin nov. sp. (Fig. I: 1, Plate I: 3, Plate II: 5)

Stromata rubra aut purpura; ab *Hypoxylon rubiginosum* differtur sporis latis vel suglobosis,  $4.5-12.0 \times 7.5-18.0\mu$ , medius  $8.0 \times 13.2\mu$ .

Stromata effuse, pulvinate or aplanate, orbicular or irregular in form, sometimes rather thin, superficial on bark or wood,  $0.7 \times 8.7 \times 0.8-23 \times 0.3-0.8$  mm. Surface of stroma smooth or wrinkled, deep purple to maroon, interior olive green to black, concolorous, undifferentiated. Perithecia entirely evident to immersed entirely, globose rather small,  $130-450 \times 250-450\mu$ . Ostioles not distinguishable, at stroma level. Asci cylindric,  $60-124 \times 7-14\mu$ ; stipes short,  $15-48\mu$ . Spores oval to subglobose, equilateral, sometimes mucronate, dark brown to black, variable in size,  $4.5-12.0 \times 7.5-18.0\mu$ , ave.  $8.0 \times 13.2\mu$ .

*South African Hosts: Passerina falcifolia.**Material examined:*

Martin 68, 110, 555; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959). Martin 1791 ex Carroll 169; Dominical, Costa Rica, (1962).

*Cultural characters* (Plate III: 3, Plate IV: 12):

Colonies velvety, opaque, gleaming white, with a coarse surface. Margin distinct, 3—5 mm. broad, peripheral hyphae lying together. Stain none. Growth rate moderately fast, 3.7 mm/day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $2.3\mu$ . Secondary mycelium reticulate, forming a close net-work; hyphae  $2.0-2.8\mu$  in diameter.

*Conidiophores and conidia:* Sterile.

This strain like the previous one is hard to classify. The writer has given it specific rank on the grounds of superficial stromal differences from *H. rubiginosum*, the subglobose dark coloured spores, and its occurrence in more than one geographic area.

12. *Hypoxylon vogesiacum* Pers. ex Sacc. (Plate II: 8)

Currey F. Trans. Linn. Soc. Lond. **22**, 269, (1859). Miller J. H. Mycologia **25**, 325-326, (1933); Monog. Univ. Puerto Rico **B**, **2**, 207, (1934); World Species of *Hypoxylon*, **34**, (1961).

sub *Sphaeria vogesiaca* Pers. ex Sacc.

Persoon C. H. in Litt. Moug. et Nestl: Stirp. Vog.-Rhen. no. 765, (1823).



Stromata aplanopulvinate, forming small glomerules on bark 3—8 mm. diameter, or irregularly effused on bark and decorticated wood,  $1.5\text{--}33 \times 3.0\text{--}49 \times 0.5\text{--}1.2$  mm. Surface of ectostroma usually light purple red to pink, sometimes maroon purple or reddish brown, smooth or wrinkled. Interior of stroma little differentiated, dark brown to ochraceous; ectostroma containing dull red particles. Perithecia evident at the vertices to completely immersed, oval,  $300\text{--}700 \times 300\text{--}800\mu$ ; ostioles sometimes not visible, raised though indistinct, or normally umbilicate as white dots on the stromal surface. Asci cylindric,  $100\text{--}230 \times 6\text{--}14\mu$ ; stipes  $22\text{--}127\mu$ . Spores equilateral, gibbous or navicular, dark brown,  $3.5\text{--}10.0 \times 9.5\text{--}20.5\mu$ , ave.  $6.6 \times 13.6\mu$ .

*South African Hosts: Olea capensis*, wood and bark.

*Material examined:*

Arnold; on *Fraxinus*, Gatineau Park, Quebec, Canada, (1957). (Mill.). Brown in Kauffmann 505 and Miller 4633; Takilma, Ore., U.S.A., (Mill.). Farlow in Miller 4620, 4627, 4628; on *Carpinus*, Shellburne, N. H., U.S.A. (1891, 1899), (Mill.). Martin 2, 3, 7, 8, 74, 144, 312, 341, 399, 453, 488, 998, 999, 1002, 1006, 1009, 1010, 1032, 1034, 1041; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959). Martin 574; Highlands Mtn. nr. Grahamstown, Eastern Cape, South Africa (1959).

*Cultural characters* (Fig. II: 4; Plate III: 5, 21):

Colonies at first closely appressed with scant subhyaline dull yellow aerial mycelium, later becoming thin velvety and nearly opaque. Colour of the mycelium becomes deep ochre with age. Surface characteristically coarse, often uneven. Margin entire, not distinct; peripheral hyphae lying together, conidia appearing after 14 days, dull red with a greenish tint, not conspicuous though profuse. Stain at first orange to orange yellow to roseate orange, very diffuse, later deepening to dark ochre yellow or coffee brown. Growth moderate,  $2.4$  mm/day at  $25^{\circ}\text{C}$ .

*Microscopic characters* (Fig. II: 13):

Primary mycelium undiagnostic. Maximum diameter of the marginal hyphae =  $2.3\mu$ . Secondary mycelium loosely organized, of long lax hyphae  $3.4\text{--}5.1\mu$  diam.

*Conidiophores and conidia:*

Conidiophores distinct from the vegetative mycelium due to the shorter branches,  $100\text{--}200 \times 1.6\text{--}1.9\mu$ , branched dichotomously or ternately to the second degree over the upper halves of the main axes. Fertile branches lying freely,  $9\text{--}30 \times 1.2\text{--}2.5\mu$ , typically mallet—or skittle-shaped with swollen, rounded or truncate apices.

Conidia borne in small apical clusters of 5—8, sessile, oval to globose, rarely somewhat pyriform, hyaline with a faint reddish tint when examined singly but collectively red-orange,  $1.4\text{--}3.1 \times 3.1\text{--}4.6\mu$ , ave.  $2.3 \times 3.7\mu$ .



This species is perhaps the most difficult to differentiate clearly from others with a reddish or purple stroma surface. Intergrades have been found by the writer whose stromal characters merge imperceptibly into *H. fuscum* or *H. rubrostromaticum*, both in this country and in North America. Culturally, however, the South African material was sharply distinct. Stromata of doubtful taxonomic position collected from California invariably yielded colonies agreeing with *H. fuscum* and were eventually assigned to that species. The writer therefore tends to base his concept of *H. vogesiacum* on South African material.

13. *Hypoxylon fuscum* Pers. ex Fr. (Fig. I: 2; Plate I: 1, 4, 9; Plate II: 10)

- Berkeley M. J. in J. E. Smith's English Flora 237, (1836); Grevillea 4, 49, (1875). Berlèse A. N. Fungi moricollae VI, 2, (1889). Berlèse A. N. & G. Bresadola Ann. Soc. Alp. Trid., 21, (1887-1888). Bizzozero G. Flora Venet. critt. 1, 200, (1885). Brefeld O. Untersuchungen aus dem Gesamtgebiete der Mykologie X. Ascomyceten 2, 259, (1891). Bresadola G. & P. A. Saccardo. Malpighia 11, 294, (1897). Cooke M. C. Handbook of British Fungi II, 796, (1871); Ann N.Y. Acad. Sci. 1, 184, (1878); Handbook of Australian Fungi 293, (1892). Cornu M. Ann. Sci. Nat. Bot. 6, 85-86, (1876). Currey F. Trans. Linn. Soc. Lond. 22, 266, (1859). Dennis R. W. G. British Cup Fungi 178, (1960). Durieu de Maisonneuve M. & J. F. C. Montagne Explor. Alger. 1, 452, (1846). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 41, (1888); N. Amer. Pyren. 633, (1892). Fries E. M. Elenchus Fungorum II, 63, (1823). Fuckel L. Symbolae Mycologicae 234, (1869-1870). Gray S. F. Natural Arrangement of British Plants 1, 513, (1821). Greville R. K. Flora edinensis 356, (1824). Hennings P. Monsumia 1, 168, (1900); Hedwigia 42, (82), (1903). Hooker W. J. Flora Scotia II, 5, (1821). Jaczewski A. L. Bull. Soc. Myc. de France 11, 123, (1895). Karsten P. A. Mycologia Fennica II Pyrenomycetes, 39, (1873). Kickx J. Flore Crypt. Flanders 307, (1867). Lambotte E. Flore Myc. Belge 420, (1880). Lindau G. in Engler & Prantl's Die Natürlichen Pflanzenfamilien I, 484-485, (1897). Miller J. H. Trans. Brit. Mycol. Soc. 15, 147, (1930); World Species of Hypoxylon 18, (1961). Nitschke T. Pyren. Germ. 1, 35, (1867). Owens C. E. Proc. Indiana Acad. Sci. 1911, 304, (1912). Persoon, C. H. Syn. Meth. Fung., 12, (1801-1808). Quélet L. Champ. Jura et Voges III, 492, (1875). Rabenhorst G. L. Deutsch. Krypt. Flor. I, 221 (1844). Rabenhorst L. Kryptflor Deutsch. II, 861, (1887). Rehm. H. Berichte Naturh. ver. Augs. 26, 56, (1881); Ascomycetes Lojkani 33, (1882). Saccardo P. D. Fungi Ital. 569, (1877-1886). Schroter J. in Cohn's Kryptflor. Schlesien 463, (1908). Starback K. Bih. Svenska Vet-akad. Handl. 15, 8, (1889). Sydow H. & F. Petrak Ann. Mycol. 20, 184, (1922). Traverso J. B. Flora Ital. Crypt. I, 44, (1906).
- sub *Hypoxylon pruinatoides* Kauffm.  
Kauffmann C. H. Pap. Mich. Acad. Sci. Arts & Letters 11, 169, (1930).
- sub *Hypoxylon rubiginosum* Pers. ex Fr. var. *tropica* Mill. Miller J. H.; World Species of Hypoxylon 31, (1961).
- sub *Sphaeria fusca* Pers.  
Albertini J. D. & L. D. de Schweinitz Conspect. Fung. 4, (1805). Fries E. M. Systema Mycologicum 332, (1823).

Stromata pulvinate to aplanopulvinate, or irregularly effuse, especially when on decorticated wood,  $0.5-11.2 \times 0.5-65 \times 0.3-2.5$  mms. Surface of stroma varying from reddish brown, red-purple to maroon or occasionally violaceous grey, and sometimes bearing superficial granulate ectostromal particles visible in longitudinal section. Interior of stroma usually differentiated, with the ectostroma lighter in hue than the darker purplish black entostroma. The ectostroma separates into purple black, deep red or vinaceous particles when squash mounts of the stromata are made, but these particles as in *H. rubiginosum* are never bright or conspicuous. Perithecia immersed or evident in outline, occasionally

evident to base, ovate,  $200-500 \times 300-700\mu$ ; ostioles umbilicate, at level with the stromal surface, usually but not always conspicuous. Asci clavate or cylindrical,  $90-240 \times 6-12\mu$ ; stipes  $24-135\mu$ . Spores oval elliptic, gibbous to navicular, medium to dark brown,  $4.5-10.5 \times 10.0-28.0\mu$ , ave.  $6.6 \times 14.3\mu$ .

*South African hosts: Curtisea faginea, Rhus legati.*

*Material examined:*

sub *Hypoxylon fuscopurpureum*

Brown; on *Amelanchier florida*, Siskiyou National forest, Takilma, Oregon, U.S.A., (1925), (AA). Dearness; on *Fraxinus*, London, Ont., Canada, (1904), (AA). Dearness; on *Ostrya virginica*, London, Ont., Canada (1904) (AA). Kauffmann; on *Liriodendron tulipifera*, Glen Echo, Md., U.S.A., (1918), (AA). Kauffmann; on *Umbellularia californica*, Siskiyou National forest, Takilma, Ore., U.S.A., (1925), (AA). Kauffmann; Rock River Mich. U.S.A., (1927), (AA). Parks 7542, 7545; on *Garrya elliptica*, Spruce Cove, Trinidad, Northern California, U.S.A., (1925), (AA).

sub *Hypoxylon fuscum*

A large quantity of material in the herbaria cited.

Martin 93, 298, 378, 411, 489, 516, 559; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959). Martin 692, 693, 694, 704, 705, 706, 711, 712, 720, 721, 722, 723, 726; Klamath National forest, Klamath, N. Calif., U.S.A., (1961). Martin 777, 778, 779; O'Brien, Shasta County, N. Calif., U.S.A., (1961). Martin 790, 810, 817, 819, 821, 825, 829, 830, 848, 849, 850, 851, 855; Arcata, N. Calif., U.S.A., (1961). Martin 892; culture only, ex Centraal bureau voor Schimmelcultures, Baarn, (1961). Martin 898; ex C. Booth (CMI), Surrey, England, (1961).

sub *Hypoxylon oregonense*

Brown (det. Kauffmann); On *Amelanchier florida*, Takilma, Oregon, U.S.A., (1925), (AA).

sub *Hypoxylon pruinosoides*

Brown (det. Kauffmann); on *Corylus californica*, Takilma, Ore., U.S.A., (1925), (AA).

sub *Hypoxylon rubiginosum*

Kauffmann & Mains; Lake Placid, N.Y., U.S.A., (1914), (AA). Wehmeyer; on *Betula*, Elkmont, Tenn., U.S.A., (1924), (AA).

sub *Hypoxylon vogesiacum*

Brown; on *Acer circinatum*, Siskiyou National forest, Takilma, Ore., U.S.A., (1925), (AA). Kauffmann in Miller 4653; on *Salix*, Medicine Mtns., Wyo., U.S.A., (Mill.). Kauffmann & Brown; on *Athus*, Quiniault, Wash., U.S.A. (1925), (AA). Kauffmann & Wehmeyer; Mt. Hood, Ore., U.S.A., (1922), (AA).

*Cultural characters* (Plate III: 6-7; Plate IV: 11, 13; Plate V: 10):

Colonies velvet to velvet-felty, sometimes somewhat cottony or floccose, usually with a coarse texture developing at least with age, pure or dull white, partly discoloured amber, cream or dull yellow. Margin not distinct, peripheral hyphae compact. Conidia rarely produced immediately, usually developed with age, and sometimes absent entirely; forming a thin fawn or dull orange brown crust. Stain dark red, reddish orange or roseate, produced up to the margin and deepening in intensity towards the centre, rarely amber or ochraceous or absent. Growth slow to moderate,  $0.3-3.6$  mms/day at  $25^{\circ}\text{C}$ .

*Microscopic characters:*

Primary mycelium undiagnostic. Maximum diameter of the marginal hyphae =  $2.7\mu$  diameter; in most species the range extends through  $1.2-1.8\mu$ . Secondary mycelium often absent; when developed it is uniform, ropy or reticulate,  $1.5-5.6\mu$  in diameter.

*Imperfect Stage:* (Fig. II: 7; Plate IX: 1-4)

Brefeld O. Untersuchungen aus dem Gesamt. Myk X. Ascomyceten 2, 259, (1891).  
 Jaczewski A. L. Bull. Soc. Myc. de Fr. 11, 123, (1895). Lindau G. in Engler & Prantl:  
 Die Natürlichen Pflanzenfamilien I, 484, (1897).

The conidiophores fall into three types, but there is no apparent correlation between them and character of either stroma or mycelial colony.

- I. The commonest type (*Sporothrix-Calcarisporium* I-II) is relatively short in comparison with that of previous species,  $25-320 \times 1.2-2.3\mu$ , unbranched or branched to a varying degree over the length of or only at the terminal portion of the main axes. Branching is dichotomous, ternate or quadrate; and fertile branches lie freely or in trident formation. Fertile branches are  $8-96 \times 1.2-2.2\mu$ , with unspecialized or distinct globose heads, and smooth walls. The conidia are acrogenous, or in fascicles from the fertile branches or in random groups off the hyphae, on slender or stout sterigmata, or sessile, clavate or elliptic, sometimes approaching pyriform, with narrow bases, fawn brown, red brown, rarely white en masse,  $1.0-2.5 \times 3.2-7.0\mu$ , ave.  $2.0 \times 4.5\mu$ .
- II. This type, (*Sporothrix-Calcarisporium* IV-V), differs from the main one in repeated verticillate branching. Conidiophores are  $150-210 \times 1.5-1.8\mu$  with rather delicate fertile branches  $13-41 \times 1.2-1.5\mu$ , in trident formation. Conidia as above, on stout peg-like sterigmata, clavate, fawn brown,  $1.2-2.2 \times 3.7-5.0\mu$ , ave.  $1.8 \times 3.5\mu$ .
- III. This type intermediate between *Sporothrix* II and *Acrostaphylus*, is distinguished by the dull brown tint and warted walls of the conidiophores and has been found to develop late in association with (I). Conidiophores are  $85-255 \times 1.2-4.3\mu$ , stout, with fertile branches  $12-28 \times 1.8-2.5\mu$  lying freely or in trident formation. Conidia as above, sessile, equilateral, often botuliform, thin walled, white,  $2.5-3.1 \times 4.3-5.5\mu$ , ave.  $2.8 \times 4.9\mu$ .

## PLATE VII Microscopic characters.

- 1-2. *Hypoxyton oodes*
  1. *Sporothrix* type III,  $\times 210$
  2. *Sporothrix* type II,  $\times 210$ . Inset: Details of spores,  $\times 540$
3. *Sporothrix schenckii*,  $\times 210$ , for comparison
4. *Hypoxyton albstigmatosum*
- 5, 8. *Sporothrix* type II,  $\times 210$ . Inset: Details of spores,  $\times 540$
5. *Hypoxyton subchlorinum*
  5. *Sporothrix* type I: conidia mainly in fascicles,  $\times 210$
  8. *Sporothrix* type III: showing sympodial branching,  $\times 210$
6. *Hypoxyton occidentale*
7. *Sporothrix* type II,  $\times 210$
7. *Hypoxyton fragiforme*
7. *Sporothrix* type II,  $\times 210$
- 9-10 Reticulate-tentacular secondary mycelium
  9. *Hypoxyton subchlorinum*
  10. *Hypoxyton howeanum*





14. *Hypoxylon rubrostromaticum* Miller. (Plate I: 4)

Miller J. H. World Species of *Hypoxylon* 24, (1961).

sub *Hypoxylon glomerulatum* Theiss.

Rick J. Broteria ser. bot. 25, 27, (1931). Theissen F. Ann. Mycol. 6, 345, (1908); Ibid 7, 145, (1909).

sub *Hypoxylon haematites* Lév. var *macrospora* Theiss.

Theissen F. Ann. Mycol. 6, 345, (1908); Ibid 7, 145, (1909).

Stromata aplanopulvinate, of varying extent,  $1.5-21 \times 1.8-98 \times 0.6-1.4$  mms. Surface maroon purple or red purple; ectostroma brittle refractive, vinaceous to black at sight, yielding vinaceous particles in microscopic preparations; entostroma well developed, corky, dull brown to black. Perithecia adjacent, evident entirely to completely immersed, ovate,  $200-700 \times 400-800\mu$ ; ostioles clearly umbilicate or not visible. Asci cylindric,  $130-160 \times 12-14\mu$ ; stipes  $42-60\mu$ . Spores gibbous to navicular with narrow ends, enclosed in hyaline sheaths, dark brown to black,  $5.5-10.5 \times 12.0-22.5\mu$ , ave.  $7.7 \times 17.5\mu$ .

## Material examined:

Chardon & Toro in Miller 4650; Los Morros, Aragua, Venezuela, (1932), (Mill.). Martin 1067, 1068, 1070; ex Schroeder, Linda S'Dia, Costa Rica, (1962). Martin 1191; Nature's Valley, Knysna District, Western Cape, South Africa, (1962). McKenzie; New Zealand, (1925), (Mill.). Miller 2738 ex Theissen; Sao Leopoldo, Brazil, (Mill.).

sub *Hypoxylon vogesiacum*

Kauffmann in Miller 4653; on *Salix*, Medicine Mtns., Wyo., U.S.A. (Mill.). Shear; on *Rubus jamaicensis*, Maunaloa, Hawaii, (NFC). Thaxter 6880; St. Anne's Valley, Port of Spain (NFC), Trinidad, (1912-1913), (Mill.).

## Cultural characters (Plate IV: 9; Plate V: 11):

Colonies cottony to velvet felty, with coarse texture, pure white. Mycelial aggregates absent. Margin not distinct; hyphae lying together. Conidia formed by 7 days, but not conspicuous. Stain absent. Growth fast,  $5.1-6.3$  mm/day at  $25^{\circ}\text{C}$ .

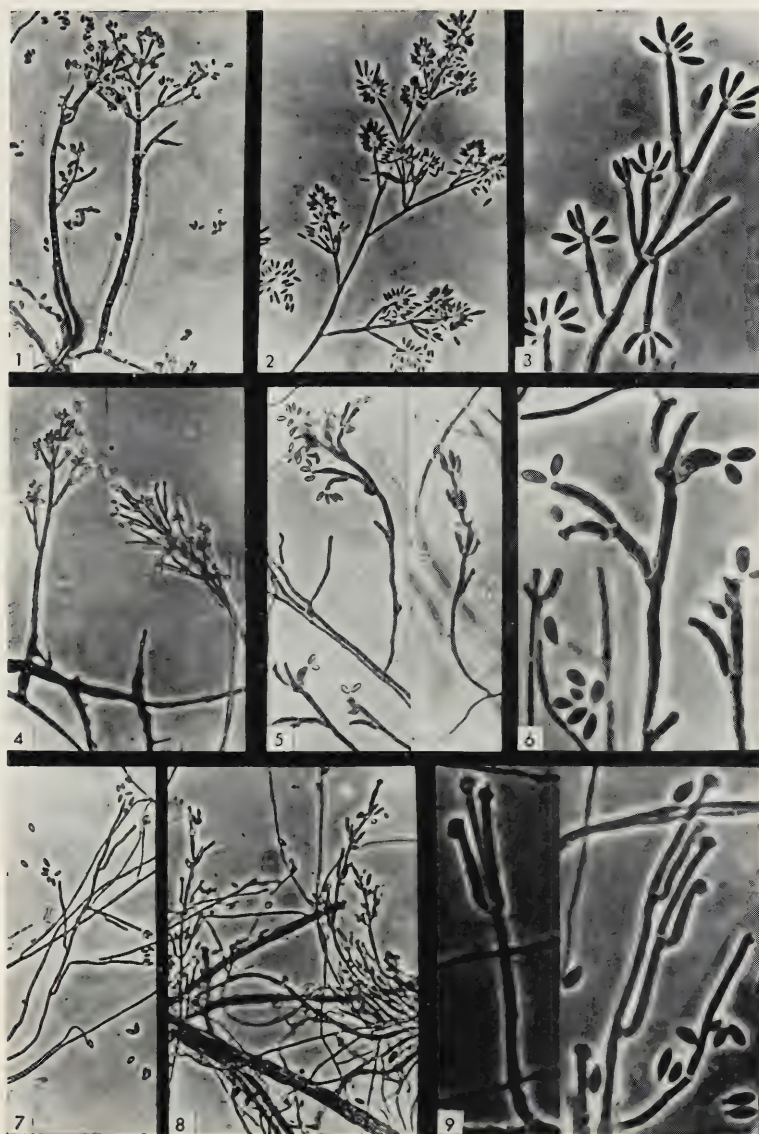
## Microscopic characters (Plate IV: 5-6; Plate IX: 9):

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $2.3\mu$ . Secondary mycelium absent.

## PLATE VIII Microscopic characters (continued).

- 1—3. *Hypoxylon dieckmanni*
  1. Arborescent conidiophore with warted main axis (*Sporothrix* type IV),  $\times 210$
  2. Upper part of dendroid conidiophore with smooth main axis,  $\times 210$
  3. Details of above,  $\times 540$
4. *Hypoxylon riograndense* (*Sporothrix* type IV),  $\times 210$
- 5—6. *Hypoxylon rubrostromaticum*
  5. Dendroid and compact conidiophores (*Acrostaphylus*),  $\times 210$
  6. Details of above,  $\times 540$
- 7—9. *Hypoxylon bicolor*
  7. Conidiophores with dichotomous branching (*Sporothrix* type II),  $\times 210$
  8. Conidiophores with verticils and tridents (*Sporothrix* types IV—V), also ropy secondary mycelium,  $\times 210$
  9. Details of fertile branches, showing flaring heads,  $\times 540$





*Conidiophores and conidia:*

Conidiophores distinct on account of their dark brown tint and warted walls,  $100-500 \times 1.5-2.7 \mu$ , branched indefinitely over the supporting axes, with 2-3 branches at each junction. Fertile branches narrow or swollen, lying free or in trident formation, with unspecialized heads,  $8-25 \times 1.2-3.1 \mu$ . Conidia acrogenous, sessile, clavate with broad bases, fawn en masse,  $1.5-2.5 \times 3.7-5.0 \mu$ , ave.  $2.1 \times 4.5 \mu$ . This type normally conforms to *Acrostaphylus* but may vary towards *Sporothrix* II.

**The Hypomiltum Series**

*Hypoxylon hypomiltum* has been doubtfully separated from *H. rubiginosum* by Miller (1961, p. 39) on account of a "blood-red subsurface". Miller's description, furthermore, refers to a fairly large effused species with conspicuous bright colouration. The writer has found that this covers only one of the many variants with brightly coloured stromata, and that there is a series leading from *H. rubiginosum*, beginning with forms that differ only in brighter subsurface colouration, to others with brighter superficial colouration and larger spore size. Some of these forms were originally merged with *H. rubiginosum* by Miller.

**15. Hypoxylon bicolor E. & E. (Plate II: 11, 12)**

Ellis J. B. & B. M. Everhart Jour Mycol 2, 88 (1886).

?sub *Hypoxylon ianthinum* Cke.

Cooke M. C. Grevillea 11, 132, (1883). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 89, (1887); N. Amer. Pyren. 650, (1892).

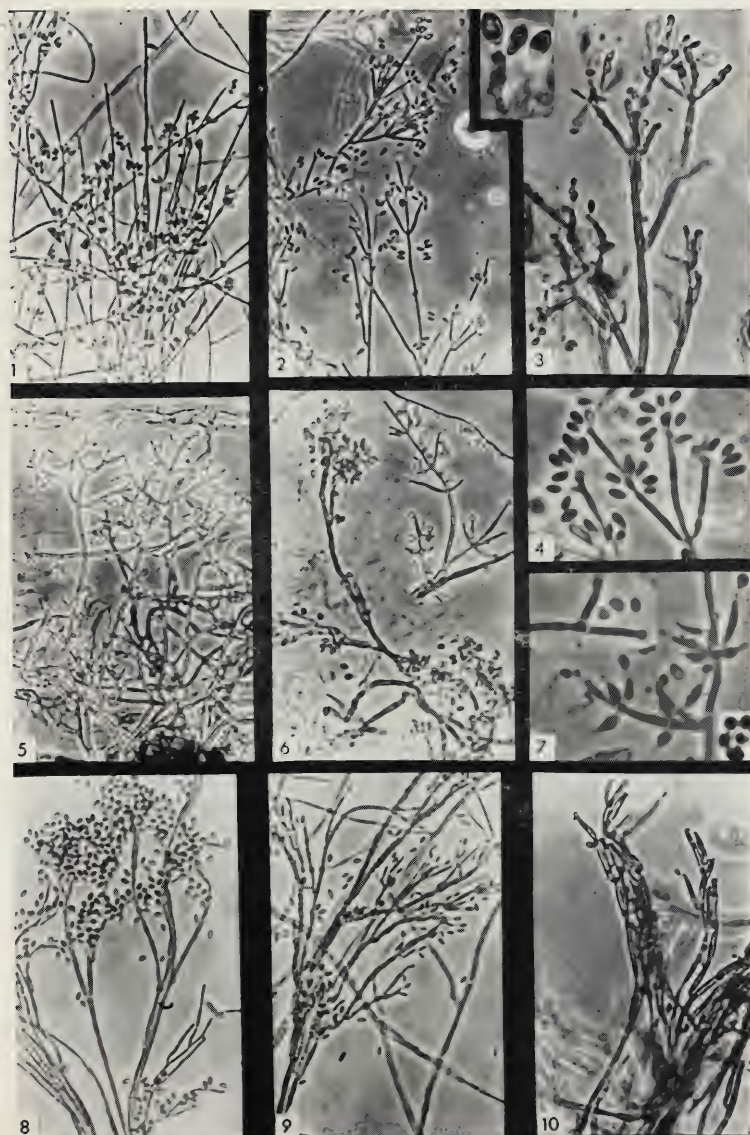
?sub *Nummularia ianthina* (Cke.) Lloyd

Lloyd C. G. Myc. Writ 7, 1312, (1924).

Stromata pulvinate or aplanopulvinate, superficial, varying in form, but never large and consistently effuse,  $1.1-22 \times 1.7-87$  mms. Surface colouration light purple, ferruginous, ochraceous yellow, or white, frequently with a mixture of colours in the same stroma or set of stromata. The initial stage is yellow. Ectostroma usually brittle refractive when broken, disintegrating into

**PLATE IX Microscopic characters (continued).**

- 1-4. *Hypoxylon fuscum*: conidiophore types
  1. *Sporothrix* type I, with fascicles of conidia  $\times 210$
  2. *Sporothrix* type IV, narrow verticillate  $\times 210$
  3. *Sporothrix* type II stout, approaching *Acrostaphylus*  $\times 210$   
Inset:  $\times 540$
  4. Details of (2): trident with fascicle of conidia  $\times 540$
- 5-7. *Hypoxylon hypomiltum*
  5. Trichodermoid conidiophores (*Sporothrix* type V)  $\times 210$
  6. *Sporothrix* type II  $\times 210$  cf. (3) above
  7. Detail of fertile branches and conidia  $\times 540$
- 8-10. Conidiophores intermediate between *Sporothrix* and *Acrostaphylus*
  8. *Hypoxylon croceopileum*  $\times 210$
  9. *Hypoxylon rubrostromaticum*  $\times 210$
  10. *Hypoxylon jecorinum*  $\times 210$





yellow or orange particles in microscopic preparations. Entostroma well developed, dark coloured. Perithecia evident at vertices to completely immersed, usually fairly closely crowded, globose to ovate,  $200-700 \times 200-1000\mu$ ; ostioles usually clearly umbilicate, sometimes not visible; periphyses rarely conspicuous at the ostiolar mouths. The stromal interior tends to disintegrate in tropical specimens leaving a hollow shell beneath the ostiolar mouths. Asci cylindric,  $80-180 \times 5-8\mu$ ; stipes  $27-112\mu$ . Spores oval-elliptic, equilateral or navicular, light to dark brown,  $3.5-7.5 \times 7.5-15.0\mu$ , ave.  $5.0 \times 10.2\mu$ .

*South African hosts: Canthium spinosum, Cassine croceum, Curtisia faginea, Passerina falcifolia.*

*Material examined:*

sub *Hypoxylon bicolor*

Langlois; Nuttallburg, Va., U.S.A., (1893), (NYBG). Martin 222; Hogsback, nr. Alice, Eastern Cape, South Africa (1958). Martin 287, 325, 326, 330, 405, 469, 482, 492, 499, 562, 1042; Nature's Valley, Western Cape, South Africa, (1958, 1959, 1962). Martin 698, 729, 730, 731; Klamath, Northern California, U.S.A., (1961). Martin 772; O'Brien, Northern California, U.S.A., (1961). Martin 841, 842, 870, 874; Arcata, Northern California, U.S.A., (1961). Martin 905, 907, 908, 920-922, 924, 942, 944, 946; Mazatlán, Sinaloa, Mexico (1961). Martin 952, 955, 956, 957, 991, 1500, 1549; San Blás, Nayarit, Mexico (1961, 1962). Martin 1084, 1105; Columbia, Mo., U.S.A. (1962). Martin 1110, 1111-1114, 1116-1120, 1114, 1153, 1159, 1176; Lake Ozark, Mo., U.S.A., (1962). Martin 1633, 1638; Nyack Village, N.Y. State, U.S.A., (1963). Martin 1642; Lake Sebago, N.Y. State, U.S.A., (1963); Martin 1677, 1679, 1690-1694, 1736, 1737, 1741. Conway State Forest, Mass., U.S.A., (1963). Martin 1705; Mt. Toby, Mass., U.S.A., (1963). Martin 1725, 1729, 1732-1735; Savoy State Forest, Mass., U.S.A., (1963).

sub *Hypoxylon hypomiltum*

A wide range of material in the AA, CMI and other herbaria.

sub *Hypoxylon ianthinum*

Ellis 396; Clyde, N.Y. State, U.S.A., (1887), (NYBG). Ellis N. Amer. Fungi 1182, Bethel, Colo., U.S.A., (0000), (NYBG).

*Cultural characters* (Plate III: 8-10; Plate IV: 16, Plate V: 1-2):

Colonies velvety to felty, sometimes somewhat fleecy or cottony, of varying density, but with characteristically fine texture and smooth surface. Mycelial aggregates absent in contrast to *H. rubiginosum*. Colour of mycelium highly variable, basically pure or dull white but usually developing areas of brighter colour such as yellow, orange, or red-brown, from the centre outwards. Margin not distinct or forming a submersed zone 5-15 mm. wide, compact. Conidia sparsely developed, rusty red, occasionally dense and conspicuous, produced after 1 week or only with age. Stain variable, sometimes absent, normally some shade of reddish brown, more rarely amber, rose, reddish orange, dull buff brown or brandy colour. Appearance on other media essentially similar, but less luxuriant on maize and Czapek. Growth rate variable among strains, usually moderate, but varying from slow to fast,  $1.7-6.8$  mm/day at  $25^{\circ}\text{C}$ .

*Microscopic characters* (Fig. II: 1):

Primary mycelium undiagnostic; max. diameter of marginal hyphae =  $2.6\mu$ .

Secondary mycelium sometimes absent; when present loosely organized to ropy, rarely reticulate,  $1.5\text{--}4.5\mu$  diameter.

*Conidiophores and conidia* (Plate VIII: 7-9):

Conidiophores little differentiated to distinct,  $9\text{--}1110 \times 1.5\text{--}3.1\mu$ , unbranched to branched indefinitely over most or part of the main axes. Branching varies from dichotomous only to ternate or repeatedly verticillate, with the fertile branches lying freely or in trident formation. Fertile branches unspecialized or with distinct globose heads,  $3.7\text{--}142 \times 1.2\text{--}2.5\mu$ . Conidia clavate or pyriform, narrow based, sessile or on slender sterigmata, ochraceous, fawn brown, or ferruginous,  $1.8\text{--}4.3 \times 3.1\text{--}7.5\mu$ , ave.  $2.4 \times 4.9\mu$ . It is in the imperfect characters that this species shows the greatest difference from *H. rubiginosum*.

**16. *Hypoxylon viridicolor* Martin, nov. sp.**

Stromata aplanopulvinata, viridis; ab *Hypoxylon bicolor* differtur pigmento.

Stromata aplanopulvinate, of restricted extent,  $2.3\text{--}5.0 \times 6.0\text{--}8.0 \times 0.7 \times 1.0$  mm. Surface of initial stage and ectostroma olive green; interior of ectostroma refractive, disintegrating into yellow green particles. Ectostroma and entostroma not sharply differentiated but the latter is darker. Perithecia vaguely evident, ovate,  $500\text{--}700 \times 600\text{--}800\mu$ , adjacent but not close crowded; ostioles not visible. Asci not seen. Spores navicular, with narrow ends, dark brown,  $4.5\text{--}7.0 \times 9.5\text{--}15.0\mu$ , ave.  $5.1 \times 11.7\mu$ .

*South African hosts unidentifiable*

*Material examined:*

Martin 487, Nature's Valley, Knysna District, Western Cape, South Africa, (1959).

*Cultural characters* (Plate IV: 14):

Colonies velvet and felty smooth, forming a thin mat with a rather coarse surface, aerial mycelium white to very pale grey and tinted pale reddish brown near the centre of the colony after 7 days, changing to reddish orange with age. Margin distinct, forming a wide submersed zone 12-13 mm, hyphae lying close together. Conidia formed with age, in fawn coloured irregular pulvinate masses scattered over the whole colony. Stain red brown becoming very conspicuous beneath the aerial mycelium and usually extending about 5 mm beyond the colony border. Appearance on Leonian's medium similar, but less luxuriant on maize, and on Czapek the colonies are furrowed, with orange yellow stain. Growth rate moderate,  $2.0$  mm/day at  $25^\circ\text{C}$ .

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $3.3\mu$ . Secondary mycelium loose,  $1.6\text{--}3.4\mu$  diam.



*Conidiophores and conidia* (Fig. II: 9):

The conidiophores are similar to those described under *H. fuscum*, type III, but are not warted and are dichotomously branched. They are broader than in other species of the *H. hypomiltum* series, with axes  $2.3-3.9\mu$  in diameter, and are sometimes tinted amber, and the fertile branches narrow terminally to form peculiar hooked apices. The conidiophores are  $150-200\mu$  long, branched over most of their length; fertile branches lying freely, narrowing distally,  $10-60 \times 1.0-2.1\mu$ . Conidia pleuracrogenous or acrogenous, sessile, oval-elliptic or clavate with narrow bases, reddish brown collectively, ave.  $2.3-3.7 \times 4.0-7.4\mu$ .

17. *Hypoxyton croceoplum* Berk. & Curt. (Plate II: 13, 14)

Berkeley M. J. *Grevillea* 4, 49, (1875). Ellis J. B. & B. M. Everhart *Jour. Mycol.* 4, 89, (1887); N. Amer. *Pyren.* 651, (1892). Miller J. H. *World Species of Hypoxyton* 37, (1961). Shear C. L. *Lloydia* 10, 60, (1947).

sub *Hypoxyton ochraceofulvum* Berk. & Cke.

Cooke M. C. *Grevillea* 11, 133, (1883).

sub *Hypoxyton polyporoideum* Cke.

Cooke M. C. *Grevillea* 12, 53, (1883).

sub *Hypoxyton pumilio* Sacc.

Saccardo P. A. *Jour. Mycol.* 12, 47, (1906).

Stromata normally pulvinate or glomeruliform, up to 5 mm diameter but also aplanopulvinate and effused,  $0.9-2.5 \times 1.1-5.1 \times 0.5-1.6$  mms, superficial on bark or decorticated wood. Ectostromal surface dark red to purple red; interior scarlet refractive, displaying yellow and orange granules in microscopic mounts. Entostroma scanty, dark brown. In thin vertical section the stroma appears very pale red or pink and subhyaline when seen under the microscope, whereas sections of other species are more opaque. Perithecia are normally evident partially in outline, rather large and conspicuous, evident at the vertices, ovate to globose,  $250-450-1000\mu$ ; ostioles clearly visible or indistinct. Asci clavate or cylindric, with stipes varying greatly in length within the same sample,  $120-220 \times 8-10.5\mu$ ; stipes  $50-120\mu$ . Spores oval, navicular or crescentic, dark brown to black,  $4.5-12.0 \times 10.0-27.0\mu$ , ave.  $6.6 \times 13.7\mu$ .

*South African hosts: Leucadendron adscendens, Passerina falcifolia, Populus canadensis, Pterocelastrus tricuspidatus, Virgilia oroboides.*

This is possibly only a large-spored form of *H. bicolor*.

*Material examined:*

Kauffmann 504; Whitmore Lake, Mich., U.S.A., (1904), (AA). Kauffmann 508; on *Ulmus*, Stockbridge, Mich., U.S.A., (1928), (AA). Langlois 2154; St. Martinsville, La., U.S.A., (1889). (NYBG). Langlois 376; Pointe à la Hache, La., U.S.A., (1886), (NYBG). Martin 238; Hogsback, nr. Alice, Eastern Cape, South Africa, (1958). Martin 294, 319, 371, 383, 398; Nature's Valley, Knysna District, Western Cape, South Africa, (1958). Martin 583; Fern Kloof, Grahamstown, Eastern Cape, South Africa, (1958). Martin 1530, 1543, 1571; San Blas, Nayarit, Mexico, (1962).

**Cultural characters** (Plate III: 13; Plate IV: 17; Plate V: 8):

Colonies at first appressed, subhyaline, later dense velvet felty, white subhyaline tinted pale yellow to dull red. After 10–20 days colonies develop a pale yellow to dull red raised centre, a large pale reddish-grey intermediate zone of variable extent and a marginal zone 5–10 mm wide, submerged, colourless to white subhyaline; marginal hyphae lie close together. Eventually the centre turns dull red and secretes drops of deep red stain. Conidia are produced with age and are not conspicuous, dull red. Stain is dark red, very conspicuous, though not extending beyond the margin. Appearance on other media similar but not as luxuriant. Growth rate variable, slow to fast, 1.7–4.5 mm/day at 25°C.

**Microscopic characters:**

Primary mycelium undiagnostic, maximum diameter of marginal hyphae =  $2.3\mu$ . Secondary mycelium loose or reticulate,  $1.9$ – $6.0\mu$  diam.

**Conidiophores and conidia** (Fig. II: 5; Plate IX: 8):

Conidiophores distinct, consisting of compact ramifying systems, 150–300  $\times$  1.9–2.5 $\mu$ , colourless or tinted pink, and smooth or warted. Main axes are branched dichotomously or ternately to the second degree or indefinitely, over most of their length. Fertile branches lying freely or in trident formation, sometimes in repeated verticils, narrow with unmodified apices; 10–70  $\times$  1.0–3.1 $\mu$ . Conidia acrogenous or pleurocrogenous, sessile, clavate with narrow bases, usually with bluntly pointed ends, pink or dull red *en masse*, 1.4–2.5  $\times$  3.1–6.3 $\mu$ , ave.  $2.1 \times 4.3\mu$ . This species also shows the same variation towards *Acrostaphylus* as noted for *H. fuscum* and *H. hypomiltum*.

**18. Hypoxylon novemexicanum** Miller (Plate I: 5)

Miller J. H. World Species of *Hypoxylon* 57, (1961).

Stromata aplanopulvinate to very thinly effused, superficial on bark or decorticated wood, 1.5–5.5  $\times$  2.0–22  $\times$  0.6–1.5 mm. Surface of ectostroma smooth or minutely cracked, dull purple at maturity, rapidly darkening to black with age, characteristically overlaid with a persistent white granular or mealy covering. South African material was often shown to be infected with a parasite, *Calculosphaeria* sp. that formed protruding perithecia. Ectostroma and entostroma not clearly differentiated from each other, but dark brown to black in longitudinal section, with the former containing dull red orange particles. Perithecia entirely immersed, oval, sometimes polystichous, globose to flask shaped, 300–450  $\times$  400–800 $\mu$ , reaching the surface by short ostiolar necks; ostioles are however not visible on the surface of the stroma. Asci not observed. Spores elliptic, usually strongly inequilateral, gibbous or with one side concave, dark chestnut brown, 5.0–9.5  $\times$  12.5–19.5 $\mu$ , ave.  $7.7 \times 16.2\mu$ .

*South African hosts:* unidentifiable.

*Material examined:*

Miller 58961; Cloudcroft, New Mexico, U.S.A., (1904), (Mill.). Martin 15, 41, 292, 1001, 1021, 1022, 1038; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1962), Martin 221; Hogsback, nr. Alice, Eastern Cape, South Africa, (1958).

*Cultural characters* (Plate III: 11-12, Plate IV: 8):

Colonies thin or densely velvety, smooth, subhyaline to opaque; colour of aerial mycelium variable, basically white but usually tinged yellow or buff. Usually the centre of the colony is raised above the general level. Margin distinct, compact, forming a broad zone of submerged appressed white subhyaline mycelium 4 mm wide. Conidia are sparse, inconspicuous, dull brown, produced after 2 months. Stain at first roseate orange or brandy colour; then deepening to red brown, becoming finally black; very conspicuous through the colony and extending beyond the margin; stain also secreted as amber or roseate drops on the surface of the colony. Plate cultures on maize and Czapek show less luxuriance of growth. Growth slow, 1.6 mm/day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $1.7\mu$ . Secondary mycelium consists of long, sparingly branched, loosely associated stout hyphae  $3.5-5.0\mu$  diam.

*Conidiophores and conidia* (Fig. II: 11):

Conidiophores distinct from the vegetative mycelium by the type of branching and shorter length of the branches,  $110-130 \times 1.2-1.8\mu$ , dichotomously or ternately branched; fertile branches often in trident formation,  $13-50 \times 1.0-1.7\mu$ , usually with broad recurved apices. Conidia borne in apical clusters, oval to oval-elliptic, equilateral, dull brown collectively,  $1.4-3.1 \times 3.1-5.4\mu$ , ave.  $1.9 \times 4.0\mu$ .

**19. *Hypoxylon albstigmatosum* Spegazzini. (Plate I: 3)**

sub *Hypoxylon albstigmatosum* Speg.

Spegazzini C. Anal. Soc. Cient. Arg. 18, 271, (1884).

sub *Hypoxylon guarapiense* Speg.

Spegazzini C. Anal. Soc. Cient Arg. 18 272, (1884).

Stromata pulvinate or aplanopulvinate, superficial on decorticated wood and bark,  $1.4-16.5 \times 1.5-78 \times 0.7-1.5$  mms. Surface of stroma smooth or wrinkled, red brown or red purple as in *H. rubiginosum* but more intense in hue; interior tending to disintegrate rapidly after maturity, differentiated into a reddish brown to orange ectostroma and dark reddish-black entostroma; ectostroma refractive, unlike *H. rubiginosum*, separating into orange, yellow or vinaceous particles in squash mounts. Perithecia usually vaguely evident or immersed, rarely with prominent vertices, adjacent or in palisade formation,

ovate,  $300\text{--}500 \times 400\text{--}700\mu$ ; ostioles sometimes not visible, commonly umbilicate but not as conspicuous as in *H. rubiginosum*. Asci cylindric,  $120\text{--}145 \times 7\text{--}9\mu$ ; stipes  $48\text{--}60\mu$ . Spores gibbous to navicular, dark brown to black,  $4.5\text{--}9.0 \times 9.5\text{--}14.5\mu$ , ave.  $5.3 \times 10.7\mu$ . The spore colour also differentiates the species from *H. rubiginosum*.

*Material examined:*

sub *Hypoxylon albstigmatosum*

Balansa 2781; Guarapi, Paraguay, (1878), (NYBG). Martin 911-919, 925, 930, 941, 943, 945; Mazatlán, Sinaloa, Mexico, (1961). Martin 951, 958, 960-962, 1525, San Blas, Nayarit, Mexico, (1961, 1962).

sub *Hypoxylon guarapiense*

Balansa 2764; Guarapi, Paraguay, (1878), (NYBG).

*Cultural characters* (Plate V: 13):

Colonies felty with fine or coarse texture, dull white, without mycelial aggregates. Margin not distinct, peripheral hyphae widely dispersed. Conidia produced almost immediately, forming a reddish brown or orange brown layer. Stain absent. Growth rapid,  $6.0\text{ mms/day}$  at  $25^\circ\text{C}$ .

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $1.5\mu$ . Secondary mycelium absent.

*Conidiophores and conidia* (Plate VII: 4):

Conidiophores variable,  $70\text{--}525 \times 1.2\text{--}2.2\mu$ , branched to the second degree dichotomously or ternately over the length or upper halves of the main axes. Fertile branches lying freely or in trident formation,  $10\text{--}33 \times 1.2\text{--}2.7\mu$ , with unspecialized or slightly swollen heads. Conidia acrogenous, sessile or on stout sterigmata, clavate to pyriform, red brown or orange brown,  $1.8\text{--}3.1 \times 4.3\text{--}6.3\mu$ , ave.  $2.5 \times 5.5\mu$ .

20. *Hypoxylon occidentale* Ellis and Morgan ex Martin (Plate I: 2, 8)

Stromata pulvinate or aplanate forming linear crusts;  $2.5\text{--}53 \times 2.5\text{--}135 \times 0.5\text{--}2.0\text{ mm}$ . Surface maroon purple or deep red, sometimes smooth, but typically granulate or verrucose. Subiculum present in some samples, of fine crustose hyphae,  $1.2\text{--}3.1\mu$  diam. also purplish red or red brown. Ectostroma greenish yellow at sight or vinaceous, refractive, sometimes revealed by disintegration of the thin outer layer, and separating into vinaceous particles in squash mounts. Entostroma sharply differentiated, corky, dull brown or black. Perithecia evident at vertices to entirely immersed,  $400\text{--}600 \times 500\text{--}900\mu$ , close crowded in palisade formation, rarely simply adjacent; ostioles not visible at stromal level or raised slightly on prominences, rarely clearly umbilicate. Asci cylindric,  $90\text{--}115 \times 5\text{--}8\mu$ ; stipes  $30\text{--}45\mu$  long. Spores gibbous to navicular, dark brown,  $4.5\text{--}6.5 \times 8.0\text{--}12.5\mu$ , ave.  $5.3 \times 10.6\mu$ .



*Material examined:*

- sub *Hypoxylon dieckmanni*  
Shear; Florida, U.S.A., (1939), (NYBG).  
sub *Hypoxylon glomeratum* and *H. investiens*  
Ellis 1132; (details absent), U.S.A., (NYBG).  
sub *Hypoxylon occidentale*  
Martin 738; O'Brien, N. Calif., U.S.A., (1961). Martin 808, 846, 847, 863-865, 886;  
Arcata, N. Calif., U.S.A., (1961). Morgan 621; on *Liriodendron*, Ohio, U.S.A., (NYBG).  
Ined?  
sub *Hypoxylon subchlorinum*  
Langlois 1475; Pointe à la Hache, U.S.A., (1886), (NYBG).

*Cultural characters:*

Colonies sparse felty, with fine texture; margin not distinct, hyphae lying together. Colour at first dull white, becoming pink due to the rapid formation of conidia, always occurring under 7 days. Margin entire, compact. Stain usually roseate, sometimes ochraceous. Growth moderate, 2.5 mm/day at 25°C.

This species, *H. croceum* and *H. albstigmatosum* are analogous to *H. serpens* and other species of *Entoleuca* in colony development. (Martin 1968, p. 197).

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of marginal hyphae = 2.2  $\mu$ . Secondary mycelium loosely organized, hyphae 1.2—1.8  $\mu$  in diameter.

*Conidiophores and conidia* (Plate VII: 6):

Conidiophores 285—360  $\times$  1.8—2.3  $\mu$ , little differentiated, unbranched to indefinitely branched over the upper halves or terminal parts of the main axes. Branching is dichotomous or ternate; fertile branches 15—28  $\times$  1.8—2.3  $\mu$ ; lying freely, rarely in trident formation, usually with slightly swollen or distinctly globose apices. Conidia acrogenous or in fascicles up the fertile branches, on slender sterigmata, pyriform with narrow bases, pink collectively, 1.8—2.5  $\times$  3.7—6.3  $\mu$ , ave. 2.3  $\times$  4.7  $\mu$ .

21. *Hypoxylon subchlorinum* Ellis and Calkins

Ellis, J. B. & B. M. Everhart. Jour Mycol 4, 86 (1888).

Stromata similar to *H. occidentale* in broad respects but thinner and not as extensive, pulvinate to aplanate; 2.5—18  $\times$  5.0—110  $\times$  0.3—1.2 mm. Surface purple-red or reddish brown, but smooth, unlike *H. occidentale*; subiculum also present of the same colour. Ellis notes on the type material (Calkins, 1886) that the stroma was greenish-yellow inside; the present writer could not confirm this but frequently saw conspicuous yellow or orange particles in herbarium and collected material. Entostroma slight, dull brown to black. Perithecia evident at vertices to vaguely so, ovate, 150—600  $\times$  200—900  $\mu$ ; close crowded in palisade formation; ostioles usually indistinct, sometimes raised on conic protuberances. Asci not seen, reported as cylindric, with the sporing part 60—65  $\times$  7  $\mu$ . Spores



gibbous to navicular, medium to dark brown,  $3.5-7.0 \times 7.5-12.5\mu$ , ave.  $4.9 \times 10.3\mu$ .

*Material examined:*

sub *Hypoxylon investiens*

Shear 5819; (details absent), (NYBG).

sub *Hypoxylon subchlorinum*

Calkins in Ellis & Everhart, N. Amer. Fungi 2115, Jacksonville, Fla., U.S.A., (1886), (AA), (NYBG). Kauffmann; Brooksville, Fla., U.S.A., (1919), (AA). Martin 1630-1632; Nyack village, Rockland Co., N.Y. State, U.S.A. (1963). Martin 1730; Savoy State Forest, Mass., U.S.A., (1963).

*Cultural characters* (Plate V: 5):

Colonies cottony, dull white, with fine or coarse texture; margin not distinct, with compact hyphae.

Mycelial aggregates present in moderate quantity. Conidia formed by 7 days but not conspicuous. Stain ochraceous. Growth rate moderate, 3.3 mm/day at 25°C.

*Microscopic characters* (Plate VII: 9):

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $1.2\mu$ . Secondary mycelium reticulate-tentacular (cf. *H. howeianum*); hyphae  $1.2-1.8\mu$  diam.

*Conidiophores and conidia* (Plate VII: 5, 8):

Conidiophores distinct from the vegetative mycelium on account of their sympodial development (cf. *H. aureostroma*),  $2.0-660 \times 1.2\mu$ ; main axes unbranched or branched to the first degree.

The axes of the conidiophores are made up of successive fertile side branches, each of which terminates in a cluster of conidia. Fertile branches also bear fascicles of conidia off their sides, and vary greatly in length,  $15-198 \times 1.2-1.8\mu$ . The conidia are sessile, clavate with narrow bases, white,  $1.8-2.5 \times 4.7-7.5\mu$ , ave.  $2.3 \times 5.7\mu$ .

**22. *Hypoxylon hypomiltum* Mont. (Plate II: 15)**

Berkeley M. J. & C. E. Broome Jour. Linn. Soc. Lond. **14**, 121, (1875). Miller J. H. Bothalia **4**, 257, (1942); World Species of *Hypoxylon* 38, (1961). Montagne J. F. C. Ann. Sci. Nat. **11** 13, 7, 56, (1840); in Gray: Hist. Chile VII, 444, (1850); Syll. Crypt. 214, (1856). Petch T. Ann. roy. bot. gard. Perad, **8**, 156, (1924). Sydow H. & P. & E. J. Butler Ann. Mycol. **9**, 416, (1911).

sub *Hypoxylon fendleri* Berk. & Cke.

Cooke M. C. Grevillea **11**, 132, (1883). Ellis J. B. & B. M. Everhart Jour. Mycol. **4**, 87, (1887); N. Amer. Pyren. 646, (1892).

sub *Hypoxylon subgilvum* Berk. & Br.

Berkeley M. J. & C. E. Broome Jour. Linn. Soc. Lond. **14**, 120, (1875). Petch T. Ann. roy. bot. gard. Perad. **8**, 157, (1924). Rick J. Brotéria bot. ser. **25**, 30, (1931).

Stromata aplanate to aplanopulvinate, usually covering large areas of wood and bark,  $3-26 \times 3-43 \times 0.9-5.0$  mm, smooth, deep vivid lateritic orange to

brick red on sight. Ectostroma refractive with orange or yellow granulate particles; entostroma dark, corky. Perithecia with vertices evident or immersed, ovate, 300—500—1000 $\mu$ ; ostioles punctate umbilicate, and conspicuous or invisible. Asci cylindric, 105—130  $\times$  5—6 $\mu$ ; stipes 50—60 $\mu$ . Spores elliptic, equilateral, gibbous or navicular, medium brown, 3.5—7.0  $\times$  7.0—15.0 $\mu$ , ave. 4.7  $\times$  9.8 $\mu$ .

*South African hosts: Olea capensis.*

*Material examined:*

- Brown, Britton & Seaver 1332 & 1411b; Bermuda, (1912), (NYBG). G. W. Martin & Welden 8330; Canal Zone, Corundu, Panama, (1952), (NYBG). Martin 490; Nature's Valley, Knysna Dist., Western Cape, South Africa (1959). Parks 22003; Rarotonga, Polynesia, (1929), (AA). Shear & Stevens, on *Manifera indica*; Oahu, Hawaii, (1928), (NYBG). Smith 31; Castillo, Nicaragua, (1893), (NYBG). Weir in USDA 6517, on *Dichrostachys nutans*: Trinidad, Cuba, (1924), (AA).
- sub *Hypoxyton perforatum*  
Rick; Brazil, (1905) (AA).
- sub *Hypoxyton rubiginosum*  
Fink; Manati, Puerto Rico, (1916), (AA). Miller in UGH 5832; Bobbin Mill, Athens, Ga., U.S.A., (1928), (AA).
- sub *Nummularia lateritia*  
Ellis & Everhart N. Amer. Fungi 3033; (details incomplete), (NYBG).

*Cultural characters* (Plate IV: 15):

Colonies at first mainly canescent appressed, with a large marginal zone and centre with more developed mycelium, later velvety, opaque white with smooth fine surface. Margin distinct, submersed, 4 mm broad; hyphae close together. Conidia are developed with age, sparse, and rusty brown. Stain variable in time of appearance, but present before 1 month, deep mauve pink turning with age to rich orange red. Appearance on Leonian's agar similar, but less luxuriant on maize and Czapek. Growth rate moderate, 2.6 mm/day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; max. diameter of marginal hyphae = 3.0 $\mu$ . Secondary mycelium absent.

*Conidiophores and conidia* (Plate IX: 5-7):

Conidiophores determinate or forming an indefinitely ramifying system, 50—230  $\times$  2.5—3.2 $\mu$ , strongly verticillate with verticils repeated several times up to the main axes. Fertile branches 2—5 at each verticil, 6.6—23  $\times$  2.5—5.0 $\mu$  of two types: elongate with flaring heads and uniform in diameter, and swollen at the base with narrow heads and rather squat as in the genus *Trichoderma*. The latter are produced exclusively over the upper parts of the main axes. As the colony ages a second type of conidiophore develops (cf. *H. fuscum*) 110—230  $\times$  3.3—5.3 $\mu$  with warted walls, pale brown tint and normal branches, intermediate between *Sporothrix* II and *Acrostaphylus*. Conidia oval to subglobose, often thick walled, 3.7—4.3  $\times$  4.0—5.7 $\mu$ , ave. 4.0  $\times$  4.5 $\mu$ .

**23. *Hypoxylon haematostroma* Mont.**

- Berkeley M. J. Jour. Linn. Soc. **10**, 384, (1869). Bresadola G. & P. A. Saccardo Malpighia **4**, 301, (1890). Ellis J. B. & B. M. Everhart Bull. Lab. Nat. Hist. Linn. Iowa **2**, 415, (1893). Lloyd C. G. Myc. Writ. **7**, 1284, (1924). Miller J. H. Linn. Puerto Rico **B 2**, 201, (1934). Bothalia **4**, 257, (1942); World Species of *Hypoxylon* **36**, (1961). Montagne J. F. C. in Sagra: Hist. Cuba **344**, (1838-1842); Ann. Sci. Nat. **II 17**, 124, (1842); Syll. Crypt. **215**, (1856). Parks H. E. Univ. Calif. Publ. Bot. **12**, 50, (1926). Rehm H. Leaf. Philipp. Bot. **6**, 1944, (1913); Ibid **8**, 2958, (1916). Rick J. Broteria ser. bot. **25**, 30 (1931). Theissen F. Ann. Mycol. **7**, 149, (1909).
- sub *Hypoxylon haematites* Lév. ex Cke, non Theissen.  
Chardon C. E. Bol. R  al. Soc. Espana Hist. Nat. **28**, 121 (1928). Cooke M. C. Grevillea **11**, 133, (1883); Handbook of Australian fungi **294**, (1892). Rick J. Broteria ser. bot. **25**, 27, (1931). Theissen F. Ann. Mycol. **7**, 145, (1909).
- sub *Hypoxylon lucidum* E. & E.  
Ellis J. B. & B. M. Everhart Bull. Lab. Nat. Hist. Linn. Iowa **4**, 72, (1896).
- sub *Hypoxylon ochraceum* Henn.  
Hennings P. Hedwigia **36**, 228, (1897). Starb  ck H. Bih. Svensk. Vet.-akd. Handl. **27**, 9, (1901); Arkiv. fur bot **5**, 30, (1905).
- sub *Hypoxylon st. janianum* Ferd. & Winge  
Ferdinandson G. & O. Winge Bot. Tidskrif **29**, 14, (1909).
- sub *Hypoxylon subrutileum* Starb  ck  
Starb  ck K. Bih. Svensk vet.-akad Handl. **27**, 10, (1901).
- sub *Hypoxylon veracruceus* Berk. & Cke.  
Cooke M. C. Grevillea **11**, 129, (1883). Ellis J. B. & B. M. Everhart Jour. Mycol. **4**, 40, (1888).
- sub *Hypoxylon vividum* Berk. & Br.  
Berkeley M. J. & C. E. Broome Jour. Linn. Soc. **14**, 121 (1875). Petch T. Ann. roy. bot. gard. Perad. **8**, 154, (1924). Rick J. Broteria ser. Bot. **25**, 27, (1931). Theissen F. Ann. Mycol. **7**, 144, (1909); Ibid **9**, 159, (1911).

Stromata aplanopulvinate or pulvinate, 4—25 × 10—100 × 1.5—3.5 mm, with characteristic deep yellow to orange surface; subiculum sometimes present of closely anastomosed hyphae 1.2—2.5 µ diameter. Ectostroma refractive, orange red, separating into blood-red particles; entostroma dark coloured, well developed and corky. Perithecia evident at vertices or only vaguely so, elongate oval, 300—800 × 700 × 2000 µ; ostioles typical umbilicate. The interior of the stroma including the perithecia tends to disintegrate with age, leaving a hollow shell. Asci cylindric, 110 × 150 × 9—10 µ. Spores gibbous to navicular with narrow ends, dark brown, 5.0—9.0 × 10.0—16.5 µ, ave. 6.8 × 13.4 µ.

*Material examined:*

Carroll 136; Payap, Thailand, (1958). G. W. Martin & Welden 8599; Barro Colorado Island, Panama, (1952), (NYBG). Martin 923; Mazatl  n, Sinaloa, Mexico, (1961). Martin 965, 966, 985, 994, 1503; San Bl  s, Nayarit, Mexico, (1961, 1962). Murrill 45; Florida, U.S.A., (1923), (NYBG). Thaxter 710; Coconut Grove, Fla., U.S.A., (1897-1898), (AA, NYBG). Weir; on *Ceiba*, Santo Domingo city, Dominica, (1926), (AA).

*Cultural characters* (Plate V: 14):

This species is perhaps the easiest of those in the *Euhypoxylon* group to recognize in culture. Colonies felty, dull white subhyaline, growing thinly with fine texture; soft mycelial aggregates present in moderate quantity, formed of conspicuous secondary mycelium; margin not distinct, hyphae lying close together. Conidia develop by 7 days, in conspicuous pink balls on short, robust

erect conidiophores. Stain absent. The peculiar growth form can be studied best by placing a disc of sterilized damp blotting paper upon the culture and allowing the mycelium to grow over the surface. Growth moderate, 3.0 mm/day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of the marginal hyphae =  $1.8\mu$ . Secondary mycelium characteristic for the species, vesiculate, bead-like, loose or closely anastomosed,  $3.0$ — $13.5\mu$  in diameter.

*Conidiophores and conidia* (Plate X: 4-6):

Conidiophores fairly short and distinctive, stout, smooth or warted,  $90$ — $125 \times 2.5$ — $2.7\mu$ , branched to the first or second degree over the upper parts or at the apices; 3—5 branches arising at a single point. Fertile branches narrow or swollen clavate as in species of *Numulariola*, smooth, held in trident formation; heads unmodified;  $22$ — $30 \times 2.5$ — $3.1\mu$ . Conidia acrogenous, on slender sterigmata, broad ovate to napiform, pink *en masse*,  $2.5$ — $3.7 \times 5.0$ — $6.3\mu$ , ave.  $3.1 \times 5.8\mu$ .

24. *Hypoxyton jecorinum* Berk. & Rav.

- Berkeley M. J. *Grevillea* 4, 50, (1875). Ellis J. B. & Everhart B. M. *Jour. Mycol.* 4, 88, (1887); N. Amer. *Pyren.* 650, (1892). Miller J. H. *World Species of Hypoxyton* 39, (1961).  
 sub *Hypoxyton erythrostoma* Mill.  
 Miller J. H. *Mycologia* 25, 323, (1933).  
 sub *Nummularia cinnabarina* Henn.  
 Hennings P. *Hedwigia* 36, 227, (1897). Lloyd C. G. *Myc. Writ.* 7, 1130, (1922).

Stromata widely effused and aplanate, or aplanopulvinate and relatively small,  $2.5$ — $29 \times 3.0$ — $100 \times 0.5$ — $2.3\mu$ , with orange or orange brown surface, and bright refractive orange red subsurface corresponding to the ectostroma that sometimes reaches below the perithecia. Entostroma dark and corky; sometimes scanty. Perithecia evident at vertices or immersed, elongate ovate,  $200$ — $500 \times 400$ — $900\mu$ ; ostioles umbilicate. Asci cylindric,  $60$ — $90 \times 4$ — $6\mu$ ; stipes  $20$ — $30\mu$ . Spores oval gibbous, medium brown,  $3.0$ — $4.5$ — $6.0$ — $9.5\mu$ , ave.  $3.8 \times 7.5\mu$ .

PLATE X Microscopic characters concluded.

- 1—3. *Hypoxyton sclerophaeum* (*Acrostaphylus*)  
 1. Coremium associated with stromata  $\times 210$   
 2. Arborescent and dendroid conidiophores  $\times 210$   
 3. Detail of fertile branches and conidia  $\times 540$   
 4—6. *Hypoxyton haematostroma* (*Acrostaphylus*)  
 4. Vesiculate secondary mycelium  $\times 210$   
 5. Conidiophores  $\times 210$   
 6. Detail of fertile branches and conidia  $\times 540$   
 7—9. Coremia associated with stromata  
 7. *Hypoxyton fragiforme*  $\times 55$   
 8. Detail of (7) showing tightly woven central core,  $\times 210$   
 9. *Hypoxyton oodes*: centre more diffuse,  $\times 210$







This species appears to be a small-spored form of *H. haematostroma*, but further investigation is necessary to make a definite statement.

*Material examined:*

Murrill 104; Royal Palm Hammock, Fla., U.S.A., (1923), (NYBG). Shear; Matheson Hammock, Wade Co., Fla., U.S.A., (1940), (NYBG). Thaxter 6947; St. Ann's Valley, Port of Spain, Trinidad, (1912-1913), (NYBG).

*Cultural characters* (Plate IX: 10):

No material was available for culture.

*Conidiophores and conidia:*

Conidiophores associated with stromatic material cited above (Shear, 1940) showed some resemblance to those described for *H. viridicolor*, being intermediate between *Sporothrix* and *Acrostaphylus*. They were  $190-230 \times 2.3-5.0\mu$ , dichotomously branched over most of the main axes. Fertile branches lying free or in trident formation, occasionally 3 at a node, unspecialized or with hooked apices,  $18-50 \times 2.3-3.7\mu$ . Conidia oval to subglobose, reddish *en masse*  $3.7-5.0 \times 3.2-6.7\mu$ , ave.  $4.2 \times 5.3\mu$ .

This type resembles that described for *H. viridicolor* and is intermediate between *Sporothrix* II and *Acrostaphylus*.

The remaining species of the Hypomiltum series, *H. argillaceum* and *H. rutilum*, were not available for culture.

**The Fragiforme Series**

The members of this group bear some resemblance to those of the genus *Daldinia* to be treated in a later paper.

**25. Hypoxylon fragiforme (Pers. ex Fr.) Kickx**

Berkeley M. J. in Smith J. E.: English flora 236, (1836); Hooker's Jour. of Bot. 6, 226, (1854); Jour. Linn. Soc. 10, 384, (1896); Grevillea 4, 49, (1875). Bizzozero G. Flora veneta critt. 1, 199 (1885). Brefeld O. Untersuch. aus dem gesamt. der Myk. X, Ascomyceten 2, 260, (1891). Bresadola G. & P. A. Saccardo Malpighia 11, 294, (1897) Currey F. Trans. Linn. Soc. Lond. 22, 264, (1859). Dennis R. W. G. British Cup Fungi 177, (1960). Gwynne-Vaughan H. C. I. & B. F. Barnes Structure and Development of the Fungi 269 (1937). Hoffmann G. F. Vegetabilia cryptogamica 1, 20, (1787). Kickx J. Flore Crypt. Louvain 116, (1835); Flore crypt. Flanders 307, (1867). Miller J. H. Mycologia 20, 203, (1928); World Species of *Hypoxylon* 13, (1961).

sub *Hypoxylon coccineum* Bull.

Berlèse A. N. & G. Bresadola Ann. Soc. Alp. Trid. 14, 21, (1887-1888). Bulliard P. Hist. Champ. de Fr. 174, (1791). Hedwigia 1, 70-71, (1855). Cooke M. C. Handbook of British Fungi II, 794, (1871); Handbook of Australian Fungi 293, (1892). De Notaris G. Sferiacei Ital. 14, (1863). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 39, (1888); N. Amer. Pyren. 629, (1892). Fuckel L. Symb. Myc. 233, (1869-1870). Karsten P. A. Mycologia Fennica II, 38, (1873). Kickx J. Flore crypt. Flanders 1, 19, (1840). Lambotte E. Flore Mycol. belge 419, (1880). Lupo P. Bot. Gaz. 73, 486-495, (1922). Miller J. H. Trans. Brit. Mycol. Soc. 15, 146 (1930). Montagne J. F. C. in Gray: Hist. Chile VII, 441 (1850). Nitschke T. Pyren. Germ. 1, 28, (1867). Owens C. E. Proc. Indiana Acad. Sci 1911, 304, (1912). Petch T. Ann. roy. bot. gard. Perad. 8, 149, (1924). Quélet L. Champ. Jura et Vosges 491, (1875). Rabenhorst L. Kryptflor. Deutsch. II, 865, (1887). Saccardo P. A. Fungi Ital. 506, (1877-1886). Shear C. L. Mycologia 20, 84, (1928).

- sub *Hypoxylon dubiosum* Speg.  
Spegazzini C. Anal. soc. scient. Arg. **18**, 272, (1884).
- sub *Hypoxylon majusculum* Cke.  
Cooke M. C. & C. B. Plowright *Grevillea* **7**, 80, (1879).
- sub *Peripherostroma fragiformis* (Pens ex Fr.) Gray.  
Gray S. F. *British Plants* **I**, 513, (1821).
- sub *Sphaeria cocconea* Hooke  
Hooke W. J. *Flora Scotica* **II**, 4, (1821). Rabenhorst G. L. *Deutsch. Kryptflor* **I**, 202, (1844-1848). Sommerfelt S. C. *Supp. flor. Lapp.* 211, (1926).
- sub *Sphaeria fragiformis* Pers.  
Dickson J. *Fasc. plant. crypt. britt.* **I**, 24, (1875). Fries E. M. *Observationes mycologicae* 170, (1815); *Syst. Mycol.* 332, (1823); *Elenchus fungorum* 62, (1828); *Grevillea* R. K. *Scottish crypt. Flor.* **3**, 136, (1825). Hooke W. J. *Flora Scotica* **II**, 4, (1821). Persoon C. H. *Syn. Meth. Fung.* 9, (1801).
- sub *Valsa fragiformis* Scop.  
Scopoli J. A. *Flora Carniolica* 399, (1772).  
For other references see Miller (1961) p. 13.

Stromata pulvinate to hemispheric with circular base, normally aggregated,  $3.0-16 \times 4.0-31 \times 2.5-5.0$  mm, superficial on bark. Outer layer brick orange to orange brown, interior of ectostroma deep orange to black at sight, brittle refractive, disintegrating into orange or blood-red particles in microscopic preparations. Entostroma massive, corky, black. Perithecia evident at vertices, to completely immersed, ovate,  $200-700 \times 300-1200\mu$ , close crowded in palisade formation; ostioles not visible or clearly umbilicate,  $130-180 \times 6-9\mu$ ; stipes  $40-90\mu$ . Spores gibbous, navicular or crescentic, dark brown,  $3.5-7.5 \times 7.5-15.5\mu$ , ave.  $5.7 \times 12.0\mu$ .

*Material examined:*

*Perfect Stage:*

A large quantity of material in the herbaria cited. Martin 626 ex Barnett & Stipes 1470; Morgantown, W. Va., U.S.A., (1961). Martin 893 ex CBS, Baarn (culture only), (1961). Martin 1610 (+ *Graphium* stage); Stonybrook, Rockland Co., N.Y. State, U.S.A., (1963). Martin 1648 (+ *Graphium* stage); Roxbury, Conn., U.S.A., (1963). Martin ex Randolph; Vermont, U.S.A., (1962). Martin 1742, 1743, 1747 ex Rogerson; on *Fagus* Wine Hill, Oneonta Township, Otsego Co., N.Y. State, U.S.A., (1963). Martin 1773 ex Carroll 135; Swarthmore, Pa., U.S.A. (1963). Martin 1816 ex Carroll 104; Jylland, Denmark, (1963).

*Imperfect Stage:*

sub *Institale acariforme*

Dearness in Ellis & Everhart's *Fungi Columbiani* 2036; on *Betula lutea*, London, Ont., Canada (1904), (AA). Ellis 1328; Westchester, Pa., U.S.A., (1883), (AA). Johnson 1629; Ann Arbor, Mich., U.S.A., (1894), (AA).

sub *Isaria umbrina*

Langlois in *Flora Ludoviciana* 2199; on *Quercus*, St. Martinsville La., U.S.A., (NYBG). Merrill 1201; Youghieny River, Pa., U.S.A., (1905), (NYBG).

*Cultural characters* (Plate V: 7):

Colonies felty to velvet felty, with fine coarse texture; aerial mycelium uniformly dull white or more characteristically variegated, coloured orange, reddish or green. Mycelial aggregates sometimes present, soft. Margin sometimes lobed, not distinct; hyphae lying together. Conidia produced early or in age. Stain characteristically olive green, lightening to red-brown or red-orange to the exterior. Growth rate moderate,  $2.4-3.3$  mm/day at  $25^{\circ}\text{C}$ .

*Microscopic characters:*

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $1.5\mu$ . Secondary mycelium loose,  $1.8-3.1\mu$  in diameter.

*Imperfect stage* (Plate VII: 7; Plate X: 7, 8). See also Martin (1967), p. 232, fig. 3.

sub *Anthina flavovirens* Fr.

Fries E. M. Syst. Mycol. III, 284, 1829.

sub *Hypoxylon coccineum* Bull

Brefeld O. Untersuch. aus dem Gesamtgebiete der Myk. X. Ascomyceten 2, 260, (1891). Jaczewski A. L. Bull. Soc. Myc. de Fr. 11, 125, (1895). Schroter J. in Cohn: Kryptflor. Schlesien 462, (1908).

sub *Institale acariforme* Fr.

Fries E. M. Syst. Mycol. III, 210, (1823). Saccardo P. A. Syll. Fung. I, 353, (1882).

sub *Isaria hypoxylon* Kalchbrenner

Rabenhorst L. Hedwigia 3, 73, (1864).

sub *Isaria umbrina* Pers.

Persoon C. H. Syn. Meth. Fung. 9, 689, (1801-1808). Saccardo P. A. Atti Soc. Ven. Trent. Sci. Nat III, 152, (1873), Syll. Fung. IV, 590, (1886). Tulasne L. & C. Selecta Fungorum Carpologia II, 4, (1863).

The *Graphium*-type coremia were fairly commonly found in nature by the writer in association or connection with immature stromata, and cultures made from these were identical to those from ascospores. In contrast to the sporadic dendroid coremia of *H. cohaerens* (Papillata Group) which are otherwise similar in form, these usually form a circlet around the base of the stroma, and each member is somewhat penicillate, ochraceous to orange brown,  $70-170 \times 600-1400\mu$ . They have not been observed in culture.

Conidiophores indistinct on coremia; in culture comprising systems  $150-270 \times 1.8\mu$ , branched dichotomously to the first or second degree over the upper parts of the axes. Fertile branches lying freely, with unmodified heads,  $30-96 \times 1.2-1.8\mu$ . Conidia in fascicles off unmodified hyphae, acrogenous or pleura-crogenous, borne on slender sterigmata, clavate with narrow bases or pyriform, white collectively,  $1.5-2.5 \times 3.7-6.8\mu$ , ave.  $2.0 \times 5.0\mu$ .

## 26. *Hypoxylon howeianum* Peck.

Dennis R. W. G. British Cup fungi 177, (1960). Miller J. H. Mycologia 20, 202 and 312, (1928); Trans Brit. Mycol. Soc. 17, 125, (1932); World Species of *Hypoxylon* 15, (1961). Owens C. E. Proc. Indiana Acad Sci. 1911, 303, (1912). Peck C. 24th Report NY State Museum, 98, (1878).

sub *Hypoxylon commutatum* Nitschke

Bizzozzero G. Flora veneta. critt. 1, 199, (1885). Ellis J. B. and Everhart Jour. Mycol. 4, 40, (1888); N. Amer. Pyren. 630, (1892). Fuckel L. Symb. Myc. 233, (1869-1870). Jaczewski A. L. Bull. Soc. Myc. de Fr. 11, 127, (1895). Nitschke T. Pyr. Germ. 1, 33, (1867). Rabenhorst L. Krypt flor. Deutsch II, 863, (1887). Saccardo P. A. Fungi Ital. 567, (1877-1886). Sydow H. & F. Petrak Ann. Mycol. 20, 184, (1922). Traverso J. B. Flora Ital. Crypt. 1, 42, (1906).

sub *Hypoxylon enteromelum* (Schw.) Berk.

Berkeley M. J. Grevillea 4, 51, (1875). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 40, (1888); N. Amer. Pyren. 630, (1892).

sub *Hypoxylon multifforme* Fr. var *australe* Cke.

Cooke M. C. Grevillea 11, 129, (1883).

sub *Hypoxylon pulcherrimum* von Hohn.

Von Hohnel F. Ann. mycol. 3, 187, (1905). Lloyd C. G. Myc. Writ. 7, 1289, (1924).

sub *Sphaeria enteromela* Schw.

Schweinitz L. v. d. Trans. Amer. Phil. Soc. Philad NS 4, 190, (1832).

Stromata pulvinate to hemispheric, less commonly somewhat aplanate,  $1.2-20 \times 1.8-62 \times 1.5-7.5$  mm, superficial on bark or wood. Subiculum sometimes present, orange, of densely branched close anastomosed hyphae  $1.8-2.5\mu$  diameter. Outer layer orange brown to brick orange, entostroma refractive, deep orange to black at sight, disintegrating into orange particles in microscopic mounts. Entostroma massive, corky, black. Perithecia evident at vertices to completely immersed, close crowded in palisade formation, rarely simply adjacent, ovate,  $200-400 \times 300-600\mu$ ; ostioles invisible or clearly umbilicate. Asci cylindric,  $80-155 \times 4-8\mu$ ; stipes  $36-83\mu$  long. Spores gibbous to navicular, medium to dark brown,  $3.2-6.5 \times 6.0-11.5\mu$ , ave.  $4.1 \times 8.3\mu$ .

*Material examined:*

A large quantity of material in the herbaria cited. Martin 1698, 1699; Mt. Toby State Forest, Mass., U.S.A., (1963). Martin 1761 ex Carroll 107, Copenhagen, Denmark, (1962). Martin 1773 ex Carroll 135; Swarthmore, Pa., U.S.A., (1960). Martin 1826 ex Kramer; Lydon, Osage Co., Kansas, U.S.A., (1963).

*Cultural characters* (Plate V: 4):

Colonies felty to velvet felty, with fine texture or rarely somewhat coarse, dull white with mottled green or cream discolouration. Mycelial aggregates present, soft, sometimes extensive. Margin not distinct, hyphae lying together. Conidia usually developed early, sometimes only with age. Stain characteristically intense olive green, sometimes bottle green or greenish brown. Growth rate moderate to fast,  $2.3-7.3$  mm/day at  $25^{\circ}\text{C}$ .

*Microscopic characters* (Plate VII: 10):

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $2.5\mu$ . Secondary mycelium loose to characteristically reticulate tentacular,  $1.5-6.2\mu$  in diameter.

*Conidiophores and conidia:*

Conidiophores fairly short,  $25-210\mu$ ; axes  $0.9-1.8\mu$ , colourless or sometimes with a green tint, with smooth or warted walls, unbranched or branched dichotomously or ternately to the first degree to indefinitely over the upper parts or apices of the main axes. Fertile branches narrow or swollen clavate, with unspecialized or slightly swollen heads,  $2.5-23 \times 0.6-3.1\mu$ ; usually lying freely, sometimes in trident formation. Conidia acrogenous, sometimes also in fascicles off the hyphae, sessile or borne on slender sterigmata, clavate with narrow bases or ovate, white to cream *en masse*,  $2.5-4.3 \times 5.0-7.5\mu$ , ave.  $3.5 \times 6.0\mu$ .



27. *Hypoxylon daldiniforme* Martin, nov. sp. (Plate II: 19)

Stromata magna, globosa vel aplanopulvinata; ab *Hypoxylon mulleri* differtur pigmento aurea.

Stromata globose to aplanopulvinate, usually large but ranging greatly in size,  $6.0-28 \times 6.0-70 \times 15-22$  mm, somewhat similar to species of *Daldinia* but always sessile on the substrate. Surface of stroma smooth, bright yellow orange; ectostroma brittle refractive, saffron yellow at sight and separating into yellow particles in microscopic mounts. Entostroma massive, corky, dull brown to jet black, with 1-2 narrow concentric zones. Perithecia immersed, adjacent, globose to ovate,  $200-300 \times 600-800\mu$ ; ostioles punctate umbilicate, sometimes indistinct. Asci not seen. Spores oval, navicular to crescentic, ends narrow rounded, pale brown, subhyaline,  $3.0-4.5 \times 7.5-9.0\mu$ , ave.  $3.9 \times 8.7\mu$ .

*South African hosts:* Wood, unidentifiable.

*Material examined:*

Martin 235, 546; Hogsback, nr. Alice, Eastern Cape, South Africa, (1958, 1959).

*Cultural characters* (Plate IV: 18):

Colonies with closely appressed mycelium, canescent subhyaline to grey opaque. Margin indistinct, compact, entire or slightly lobed. Conidia inconspicuous, scattered uniformly, pink, appearing after 1 week. Stain olive green behind margin, to dull red at the centre. Growth on other media similar but without conidia; stain fiery red orange on Czapek. Growth very slow, 0.9 mm/day at 25°C.

*Microscopic characters* (Fig. II: 15):

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $2.2\mu$ . Secondary mycelium ropy, light brown,  $1.8-3.7\mu$  in diameter, forming strands of several hyphae thick.

*Conidiophores and conidia* (Fig. II: 6):

Conidiophores scarcely distinct from the vegetative mycelium,  $100-330\mu \times 1.8\mu$ , indefinitely and dichotomously branched throughout their length. The fertile branches are terete, lying freely, usually with small globose apices,  $10-25 \times 1.0-2.0\mu$ . Conidia acrogenous, in clusters of 3-8, sessile, clavate with narrow bases, pink to cineraceous *en masse*,  $1.7-2.6 \times 2.9-4.3\mu$ , ave.  $2.4 \times 3.6\mu$ .

This species appears to be close to *H. mulleri* Mill., differing in the brighter colour of the stroma.

28. *Hypoxylon sclerophaeum* Berk. & Curt. (Plate I: 13)

Berkeley M. J. Jour. Linn. Soc. 10, 383, (1869). Berkeley M. J. & M. C. Curtis Jour. Acad. Nat. Sci. Philad. II, 285, (1853). Cesati V. Atti R. acad. Scienze fisich e matem. 8, 19, (1879). Cooke M. C. Handbook of Australian Fungi 292, (1892). Miller J. H. Monog. Linn. Puerto Rico B 2, 203, (1934). World Species of *Hypoxylon* 40, (1961).



- sub *Daldinia asphalatum* (Link & Fr.) Sacc.  
Hennings P. Hedwigia 47, 259, (1908). Lloyd C. G. Myc. Writ 7, 1231, (1923). Saccardo P. A. Syll. Fung. 1, 394, (1882).
- sub *Daldinia exsurgens* Theissen  
Theissen F. Ann. Mycol. 7, 4, (1909).
- sub *Daldinia placentiformis* Theissen  
Theissen F. Ann. Mycol. 7, 4, (1909).
- sub *Hypodiscus placentiformis* (B. & C.) Rick.  
Rick J. Broteria ser. bot. V 25, 34, (1931).
- sub *Hypoxylon asphalatum* (Link & Fr.) Mont.  
Montagne J. F. C. Ann. Sci. Nat. 4, ser. 3, 118, (1855).
- sub *Hypoxylon collatum* Cke.  
Cooke M. C. Grevillea 11, 128, (1883).
- sub *Hypoxylon placentiforme* Berk. & Curt.  
Berkeley M. J. Jour. Linn. soc. 10, 383, (1869). Von Hohnel F. Denk. Akad. Wiss. Wien. mathem. nat. Klasse 83, 26, (1927).
- sub *Hypoxylon wrightii* Berk.  
Berkeley M. J. Jour. Linn. Soc. 10, 383, (1869). Berkeley M. J. and M. C. Cooke. Jour. Linn. Soc. 15, 396, (1877).
- sub *Nummularia cookeana* Rehm  
Rehm H. Leaf. Philipp. Bot. 6, 2273, (1914).
- sub *Nummularia placentiformis* (Berk. & Curt.) Sacc.  
Hennings P. Hedwigia 47, 258, (1908). Hennings P. Hedwigia 36, 228, (1897). Saccardo P. A. Syll. Fung. 1, 399, (1882).
- sub *Nummularia suborbicularis* (Welw. & Curr.) Sacc. var. *cookeana* Sacc. Saccardo P. A. Syll. Fung. 1, 399, (1882).
- sub *Nummularia wrightii* (B. & C.) Sacc. Saccardo P. A. Syll. Fung. 1, 398, (1882).
- sub *Hypoxylon nicaraguense* E. & E. Ellis J. B. & B. M. Everhart  
Bull. Lab. Nat. Hist. Linn. Iowa 2, 407, (1893).
- sub *Hypoxylon parksii* Lloyd. Lloyd C. G. Myc. Writ. 7, 1348, (1924).
- sub *Hypoxylon tahitiensis* Lloyd. Lloyd C. G. Myc. Writ. 7, 1314, (1924).

Stromata pulvinate to aplanate,  $3.2-41 \times 12-63 \times 1.8-11$  mms, initial stage tawny yellow but at maturity with reddish brown, red-purple or dull brown flat or convex surface, usually rather large and thick. Ectostroma brittle refractive, sometimes extremely hard, black at sight but disintegrating into vinaceous particles in microscopic mounts. Entostroma massive, corky to somewhat carbonaceous, dull brown to black. Perithecia evident at the vertices to completely immersed, in palisade formation, long ovate,  $400-1000 \times 700-1600\mu$ ; ostioles very small papillate, not visible, or umbilicate. Asci cylindric,  $115-140 \times 8-10\mu$ ; stipes  $40-50\mu$  long. Spores gibbous, navicular or crescentic, dark brown to black, rarely pale brown,  $5.0-8.0 \times 10.5-21.5\mu$ , ave.  $6.5 \times 12.6\mu$ .

This species is doubtfully distinct from *H. papillatum* E. & E. where the ectostroma and surface is yellow or ochraceous rather than reddish.

*Material examined:*

- Martin 1073 ex Schroeder; Guatemala, (1962). Martin 1086, 1087, 1088; Columbia, Mo., U.S.A. (1962). Martin 1507; San Blás, Nayarit, Mexico, (1962). Martin 1774 ex Carroll 137; Rachaburi, Thailand (1963). Martin 1822 ex Kramer in Herb Kansas SC 21; Leavenworth Co., Kansas, U.S.A., (1958), (with *Graphium coremial* stage). Martin 1827 ex Kramer; Lydon, Kansas, U.S.A., (1963).
- sub *Hypoxylon collabens*  
Rick; Brazil (1926), (AA).
- sub *Hypoxylon placentiforme*  
Rick in Fungi Austro americani 335; San Leopoldo, Brazil, (1907), (NYBG).

*Cultural characters:*

Colonies at first canescent, later becoming felty to cottony, with coarse texture, dull white. Mycelial aggregates slight to moderate in quantity. Margin not distinct, hyphae widely dispersed or lying together. Conidia are developed by 7 days but remain inconspicuous. Stain amber or olive green. Growth rate fast, 4.5–6.4 mm/day at 25°C.

*Microscopic characters:*

Primary mycelium undiagnostic; marginal hyphae with maximum diameter of 3.1  $\mu$ . Secondary mycelium reticulate-tentacular, as in *H. subchlorinum* and *H. howeianum*, 1.8–5.0  $\mu$  in diameter.

*Conidiophores and conidia* (Plate X: 1-3):

Coremia were observed in association with collected stromata but as they did not develop in culture they cannot be regarded as belonging to this species with certainty. These coremia occur sporadically as in *H. oodes*, are clavate, dull brown, fertile over the apices, 0.1–0.2–0.3 mm. The coremial conidiophores are smooth walled, tinted dull brown, fairly short, 39–75  $\times$  3.0  $\mu$ , unbranched or branched dichotomously to the first degree. The fertile branches are borne freely, 12–25  $\times$  2.7–3.1  $\mu$ , and bear apical conidia off slender sterigmata. The conidia are narrow pyriform, red brown, 0.6–1.2  $\times$  4.3–5.5  $\mu$ , ave. 0.9  $\times$  4.9  $\mu$ .

The conidiophores developed in culture are longer and more developed, smooth or warted, colourless or tinted dull brown, 52–210  $\times$  1.2–3.1  $\mu$ . They are unbranched or branched up to the second degree over the length of the main axes or the upper parts only. Two to four branches arise from each division. The fertile branches are borne in trident formation and are narrow or swollen clavate with the heads unspecialized to distinctly globose, 7.5–37  $\times$  1.8–3.1  $\mu$ . The conidia are acrogenous, sessile or on stout sterigmata, broad or narrow clavate to oval, yellow en masse, 2.5–4.3  $\times$  4.3–8.1  $\mu$ , ave. 3.3  $\times$  6.1  $\mu$ .

## DISCUSSION AND CONCLUSION

The description of twenty-seven species shows how difficult the classification of this section of *Hypoxylon* is. Although the use of a large number of characters undoubtedly serves to delimit the species better, the character-states do not correlate in such a way as to give broad differences that can be simply or explicitly defined. The fairly independent linkage among the characters is summarized in the table, which should be compared with that drawn up for the section *Entoleuca* (Martin 1968, p. 197). Perhaps further work on physiology and nutrition may resolve problems of specific limits that a practically exclusive morphological study has created.

CHARACTER			SPECIES SERIES		
Ectostroma with bright coloured particles	Stain on colony reverse red, violet brown or absent	Sporothrix-Calcarisporium Types I-II in culture	Stromata surface yellow/orange	<i>H. jecorinum</i>	
			Stroma surface green	<i>H. viridicolor</i>	
			Conidia rapid, profuse	<i>H. occidentale</i>	
			Stroma surface red/brown/purple	<i>H. abostigmatosum</i> <i>H. bicolor</i>	
	Types III	2nd mycelium reticulate tentacular	Stroma surface yellow/orange	<i>H. croceopileum</i>	
				<i>H. subchlorinum</i> II	
				<i>H. novemexicanum</i>	
				<i>H. bicolor</i>	
	Types IV-V	2nd mycelium close anastomosed	Stromata surface yellow/orange	<i>H. hypomilium</i>	
				<i>H. haematostroma</i>	
Acrostaphylus	Conidia elongate	stroma surface red/brown/purple	<i>H. rubrostromaticum</i>		
			<i>H. dieckmanni</i>		
Ectostroma with dull coloured particles	Stain green	Sporothrix-Calcarisporium Types IV-V	<i>H. fuscum</i>		
			<i>H. fuscum</i>		
			<i>H. vogesiacum</i> III		
			<i>H. rubiginosum</i>		
	grey	Stroma surface red/brown/purple	Stroma surface red/brown/purple	<i>H. plumbinum</i>	
				<i>H. ferrugineum</i>	
				orange	<i>H. daldiniiforme</i> IV <i>H. fragiforme</i> <i>H. howeanum</i>
				purple or various	<i>H. sclerophaeum</i>
	brown	2nd mycelium reticulate tentacular	Stroma surface red/brown/purple	<i>H. croceum</i>	
				<i>H. murcidum</i>	
Ecotostroma bright	Stain red to brown or absent	Sporothrix-Calcarisporium Type V	<i>H. riograndense</i> I <i>H. oodes</i>		
			<i>H. aureostroma</i>		
Ecotostroma dull	Stain red to brown or absent	Sporothrix-Calcarisporium Type V	<i>H. croceum</i>		
			<i>H. murcidum</i>		
Ecotostroma bright	Stain red to brown or absent	Sporothrix-Calcarisporium Type V	<i>H. riograndense</i> I <i>H. oodes</i>		
			<i>H. aureostroma</i>		

Stromata restricted;  
ostioles umbilicate

Stromata massive;  
ostioles umbilicate

Stromata commonly  
unperitheciate  
or with perithecia  
developing separately  
in stromal matrix;  
ostioles ± papillate

Of particular interest is the association of distinct types of conidiophore with various species. Five types were defined by Martin previously (1967, p. 231) and these often vary somewhat within the same species; however the range of variation is usually limited so as to make the entities comprising types I—II, IV—V and type III almost mutually exclusive.

It is type I—II that agrees closest with the type species of *Sporothrix*, *S. schenckii* (Plate VII: 3) which leads to the idea that the latter may be a degenerate form of one of the species of *Hypoxylon*. However a perfect stage for *S. schenckii* is unknown, even though it inhabits wood; conversely there is no imperfect stage of *Hypoxylon* known to be dimorphic, and the writer has not succeeded in producing such a form even with ultraviolet irradiation. Moreover the *Sporothrix* (*Sporotrichum*) imperfect stage is known for other genera in the Ascomycetes (Tubaki, 1958, p. 199, Barron *et al.*, 1961).

#### ACKNOWLEDGEMENT

The writer wishes to acknowledge the help given him by the South African Institute for Medical Research towards publication, and the assistance of Mr. Max Ulrich of the S.A.I.M.R. in preparing the photographs.

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#### ERRATA

- MARTIN, P. 1967 Studies in the Xylariaceae I. *J. S. Afr. Bot.* **33**, 205—240.  
p. 225: penultimate line, for *H. denstum* read *H. deustum*.  
p. 228: in legend, for *Sporotrichum* read *Sporothrix*. for *Hypoxylon hypomiltum* read *Hypoxylon bicolor*. for *Hypoxylon murcidum* read *Hypoxylon dieckmanni*.  
MARTIN, P. 1967. Studies in the Xylariaceae II. *J. S. Afr. Bot.* **33**, 315—328.  
p. 327: line 47, for *Gothrinum* read *bothrinum*. line 48, for *Gothrina* read *bothrina*.

A NOTE ON THE DIATOM *BACTERIASTRUM TENUE*  
STEEMANN NIELSEN

PANDORA REINECKE

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ABSTRACT

An account is given of variations in the morphology of specimens of the diatom *Bacteriastrum tenue* Steemann Nielsen, which were not indicated in the original description. The species is compared with *B. minus* Karsten.

The diatom species *Bacteriastrum tenue* was first described by Steemann Nielsen in 1931, from phytoplankton samples collected in the N.E. Indian ocean during the Carlsberg Foundation's Expedition of 1928-1930.

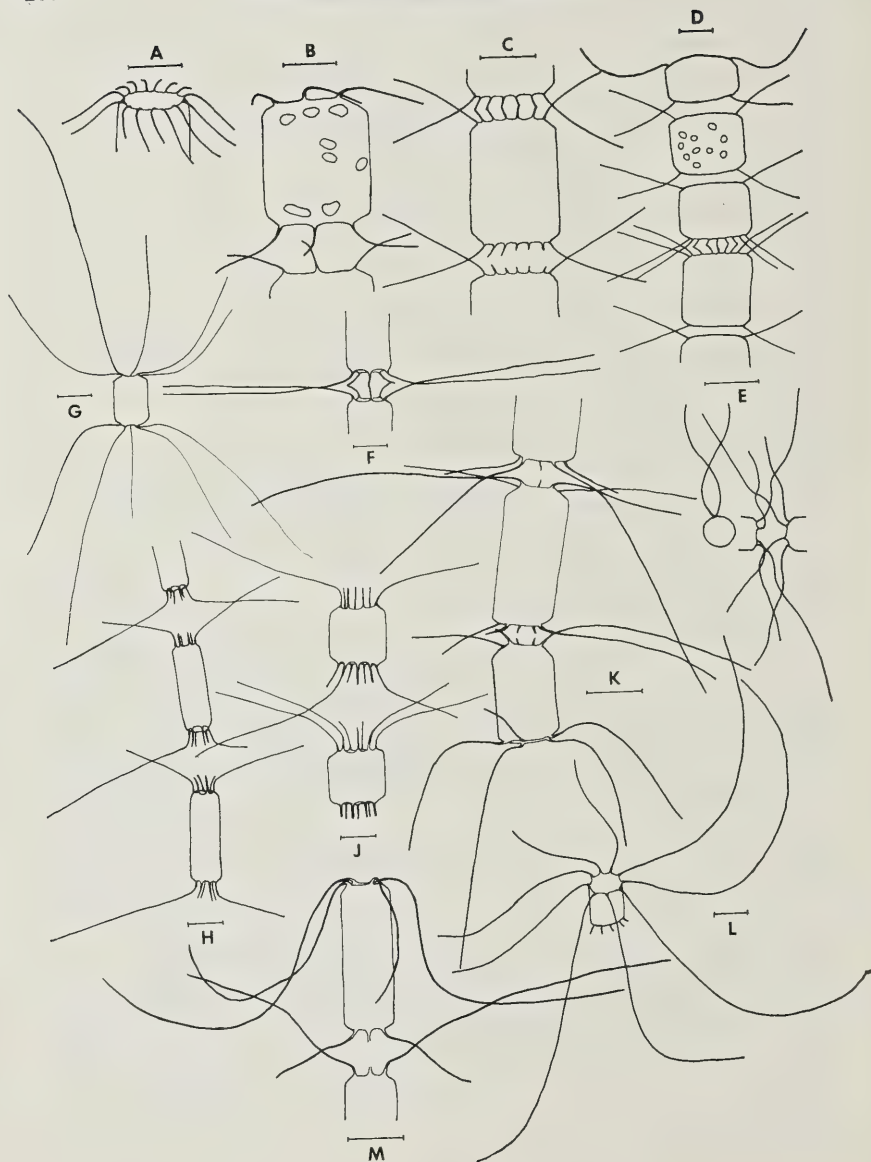
Since then *B. tenue* does not appear to have been recorded: Wood (1963), Taylor (1967) and Nel (1968). The present author has, however, found it in 44 out of 83 phytoplankton samples collected in the Agulhas current during International Geophysical Year, 1958.

The species shows considerable variation in cell dimensions, size of aperture and disposition of setae, not indicated in Steemann Nielsen's original account.

He described *B. tenue* as having elongate cylindrical cells, 6-8 $\mu$  in diameter, forming short chains with very large apertures, twice the valve diameter in size; with each valve bearing 4 setae on small processes adjoining the margin, the setae running at first almost parallel to the pervalvar axis, then curving obliquely outwards and crossing the setae of the adjacent cell at an acute angle. He writes: "Special terminal setae were not observed; once I observed a supposed terminal valve without setae. One finds mostly broken chains. Many small chromatophores. Because of its small size and the hyaline nature of the cell wall this species is easily overlooked."

Entire chains of *B. tenue* have not been observed by the present author, the longest fragment recorded being a chain of 6 inner cells. Terminal cells in chain fragments are identified by the disposition of the setae of the outer valve, (Fig. 1, B, K, L and M), otherwise, in length, thickness and the nature of the base, there is no difference between inner and terminal setae. From the curvature of the end setae, anterior and posterior terminal cells may be identified, (Fig. 1,



FIG. 1. *Bacteriastrium tenue* and *B. minus*.

B, M and K). However the setae appear to be fairly flexible, and sometimes the distinction between anterior and posterior is not really apparent, (Fig. 1, L). The number of setae per valve was found to vary from 4, (Fig. 1, M), to 9, (Fig. 1, L).

The chain aperture varies in size from approximately twice the cell diameter, (Fig. 1, H, which most approximates the specimen illustrated in Steemann Nielsen's account), to approximately half the cell diameter, (Fig. 1, K). With a decrease in aperture size, there is a decrease in the length of the basal part of the setae which runs almost parallel to the pervalvar axis.

Cell diameters of  $7-23\mu$  were recorded, and the cell length varied from approximately three times the diameter to equal to the diameter.

*B. tenue* appears to be most closely related to *B. minus* Karsten, (Fig. 1, A, C and D), on the grounds of nature of origin of the base of the setae, the intersection of the setae and the undifferentiated terminal setae. The shape of the cell in broader specimens of *B. tenue* is similar to that of *B. minus*, (Fig. 1, B and C), as is the aperture size in some specimens, (Fig. 1, C and K).

*B. tenue* differs from *B. minus* in the greater length of the setae, the greater variability of cell dimensions and aperture size and in the smaller number of setae per valve.

The lowest number of setae recorded in N.G.Y. Agulhas current samples of *B. minus* was 12 per valve, and the smallest diameter noted was  $12\mu$ ; usually it was  $16-22\mu$ . In *B. minus*, the apertures appear to be consistently small and the cells never much longer than broad. Further, long chains may be formed, (Ikari [1927]).

In the Agulhas current, *B. minus* was found in 50 out of the 83 phytoplankton samples.

Both *B. minus* and *B. tenue* were at stations throughout the area under survey, on all three of the March, May and August cruises. (For data on the Agulhas I.G.Y. stations, see Zoutendyk [1960].)

#### ACKNOWLEDGEMENTS

Work on phytoplankton in the Oceanographic Research Unit is financed by the Council for Scientific and Industrial Research.

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*Bacteriastrium tenue* and *B. minus*, from NGY stations in the Agulhas current. (For convenience sometimes only setae of one side drawn and/or entire length of setae not shown). A, C and D, *B. minus*: A, part of terminal cell; D, terminal part of chain with 16 setae per valve; C, central part of chain with 12 setae per valve; B, E, F, H-M, *B. tenue*: B and M, anterior terminal parts of chains with 4 setae per valve; L, terminal cell with 9 setae per valve; K, posterior terminal part of chain; H and J, cells from centres of chains; E, specimen with 5 setae per valve, setae unusually sinuose, resulting in configuration shown in valve view; F, specimen in which setae do not diverge after crossing; G, solitary cell of *B. tenue*? (The scale line indicates  $10\mu$ ).

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**OBSERVATIONS ON THE ANATOMY OF FOLIAR NODES OF YOUNG  
*BRUGUIERA GYMNORRHIZA* (L.) LAM.**

C. M. BREEN AND I. D. JONES

ERRATUM

Journal of South African Botany, 35, 4, 1969.

Heading at top of page 253:

for Jl S. Afr. Bot. 35 (2): etc.,

read Jl S. Afr. Bot. 35 (4): etc.

should, on the grounds of their nodal anatomy, be excluded from the Myrtiflorae.

The present work is the result of an investigation of the nodal region with particular reference to the origin of stipular and leaf vascular traces.

MATERIALS AND METHODS

*B. gymnorrhiza* is indigenous to South Africa; the material used in this investigation was collected from the mangrove forests at Kosi Bay in northern Tongaland. Material was fixed in form-acetic alcohol, passed through a butyl alcohol series and imbedded in 50° paraffin wax. Sections were cut at 10 $\mu$  on a Cambridge Rocker Microtome, stained with safranin and fast green and mounted in Canada balsam.

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Accepted for publication 6th November, 1968.

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## OBSERVATIONS ON THE ANATOMY OF FOLIAR NODES OF YOUNG *BRUGUIERA GYMNORRHIZA* (L.) LAM.

C. M. BREEN AND I. D. JONES

### ABSTRACT

An anatomical investigation of young foliar nodes of *Bruguiera gymnorhiza* (L.) Lam., has been made with particular reference to the vascular supply to the leaves and stipules. The nodal system is described and comment is made on the position of the system in hypotheses of nodal evolution in dicotyledons.

### INTRODUCTION

The stem, root and leaf anatomy of *Bruguiera gymnorhiza* (L.) Lam. has been reviewed by Metcalfe and Chalk (1950). Sinnott (1914) reports that in the Rhizophoraceae the node is trilacunar, i.e. that there are three stelar gaps associated with each leaf. Since the leaves are opposite, there would be a total of six gaps at each node. Unfortunately, he does not list the species investigated. In *B. gymnorhiza*, there are eight gaps at each node. This system has, as far as the authors are aware, not been recorded in the Rhizophoraceae. The importance of the observation is twofold: it substantiates the view of Marsden and Bailey (1955) that the multilacunar nodal system arose by addition of lateral traces and it supports the contention of Sinnott (1914) that the Rhizophoraceae should, on the grounds of their nodal anatomy, be excluded from the Myrtiflorae.

The present work is the result of an investigation of the nodal region with particular reference to the origin of stipular and leaf vascular traces.

### MATERIALS AND METHODS

*B. gymnorhiza* is indigenous to South Africa; the material used in this investigation was collected from the mangrove forests at Kosi Bay in northern Tongaland. Material was fixed in form-acetic alcohol, passed through a butyl alcohol series and imbedded in 50° paraffin wax. Sections were cut at 10 $\mu$  on a Cambridge Rocker Microtome, stained with safranin and fast green and mounted in Canada balsam.

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Accepted for publication 6th November, 1968.

## OBSERVATIONS

The primary vascular tissue is differentiated as small colateral bundles which are very close together, giving the appearance of a continuous cylinder of vascular tissue (Plate 1).

The portions of the vascular tissue that form the leaf traces become distinct from the rest of the vascular tissue some distance below the node although they do not diverge until the node. In all, eight bundles become distinguishable, the two larger bundles being opposite and in the same vertical plane as the leaves they supply. They are, therefore, termed median traces. Three traces arise, equally spaced, on each side between these median traces and are collectively referred to as lateral traces (Plate 1).

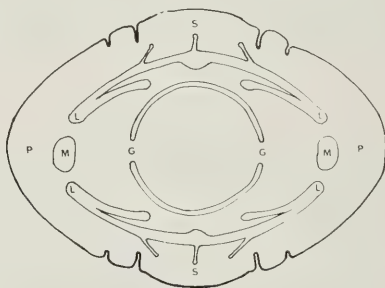


FIG. 1.

Diagrammatic representation of the vasculature of the foliar node. G, median leaf gap; L, lateral traces; M, median trace; P, base of petiole; S, base of stipule.

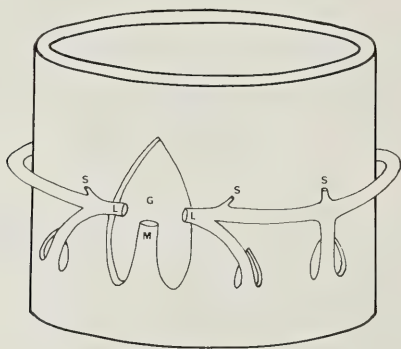


FIG. 2.

Diagrammatic representation of the vasculature of the foliar node. G, median leaf gap; L, lateral traces; M, median trace; S, stipular trace.

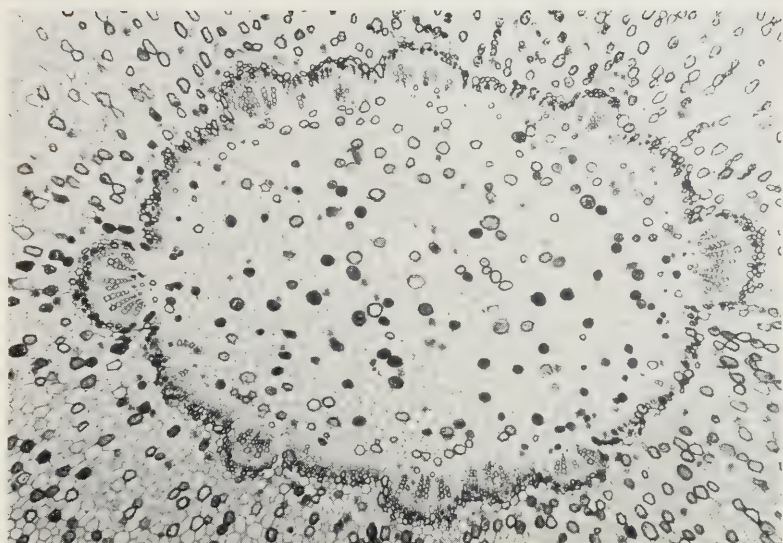


PLATE 1.

Transection a short distance below the node. The eight traces forming the vasculature of the leaves and stipules are distinguishable. The larger two are median traces.

The traces all leave the cylinder together, the median traces forming a large leaf gap whilst the lateral traces leave small gaps which close soon after the traces leave the cylinder and before they enter the leaves and stipules (Plate 2). The gap formed by the departure of the median trace does not close until after the traces have entered the leaves and stipules (Plates 4 and 5).

The median traces move obliquely through the cortex to enter the base of the petiole. The six lateral traces diverge into the cortex whence they travel vertically for a short distance before they curve round to enter the base of the petiole (Plates 3 and 4, figures 1 and 2).

The central trace of each lateral group, after diverging from the vascular cylinder, splits into two major traces which curve in opposite directions and pass into the base of the petioles. These lateral divergences meet the traces arising from the lateral positions adjacent to the median trace. The two traces become closely associated and pass together into the base of the petiole (Plate 5, figures 1 and 2). Thus they enter as one vascular strand although they are derived independently. Although the petiole appears to receive three bundles in fact it is supplied by five traces: one from the cylinder directly in line with the base

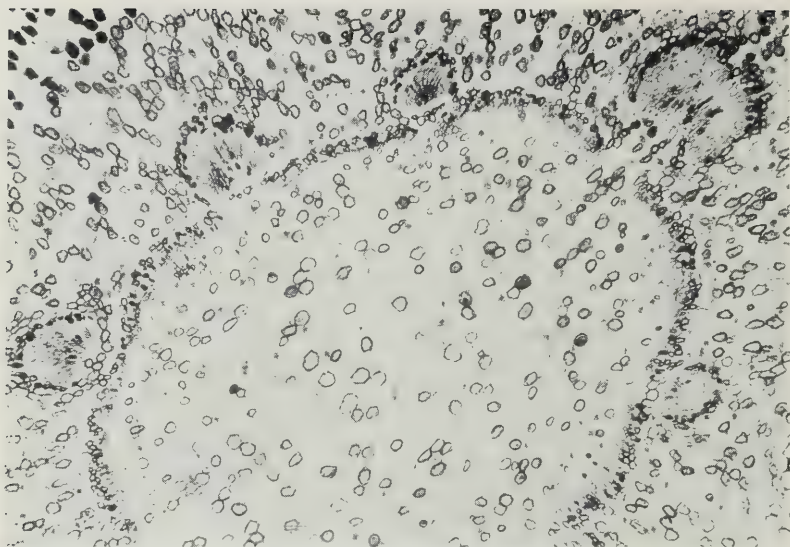


PLATE 2.

Transection of the lower part of the node. All traces leave the cylinder simultaneously. A large leaf-gap is formed where the median trace leaves the stele.

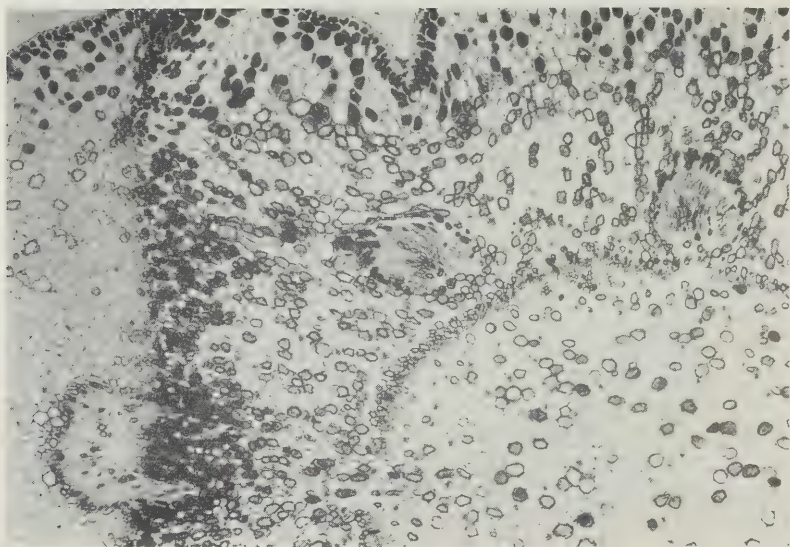


PLATE 3.

Transection through the node. The median trace enters the base of the petiole before the other traces.



of the petiole (median trace) and two on each side of this trace which are derived from the lateral traces.

The vascular supply to the interpetiolar stipules arises from the central of the three lateral traces on each side. The trace forming the mid-vein of each stipule arises at the point where the central lateral trace divides to form the traces to the leaves (Plate 6, figures 1 and 2). Each stipule has two other veins. These are positioned near the margin and they arise as small branches from the laterally diverging sections of the central lateral trace. They therefore arise in line with the margins of the stipule (Plate 7, figures 1 and 2). Each stipule receives three traces, all of which are derived from the central lateral trace.

In the nodal system, therefore, although each leaf receives five traces (making a total of ten traces), there are only eight gaps in the vascular cylinder. The system is termed multilacunar.

#### DISCUSSION AND CONCLUSIONS

In *B. gymnorhiza*, the leaves are opposite and the stipules are inter-petiolar. Each leaf receives five traces although there are only eight gaps in the vascular

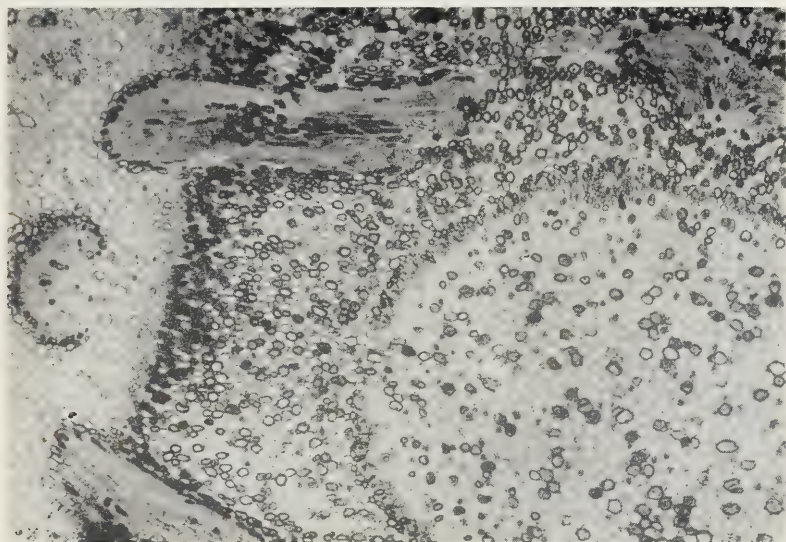


PLATE 4.

Transection through the node. The lateral traces enter the base of the petiole together. Each petiole receives five traces.



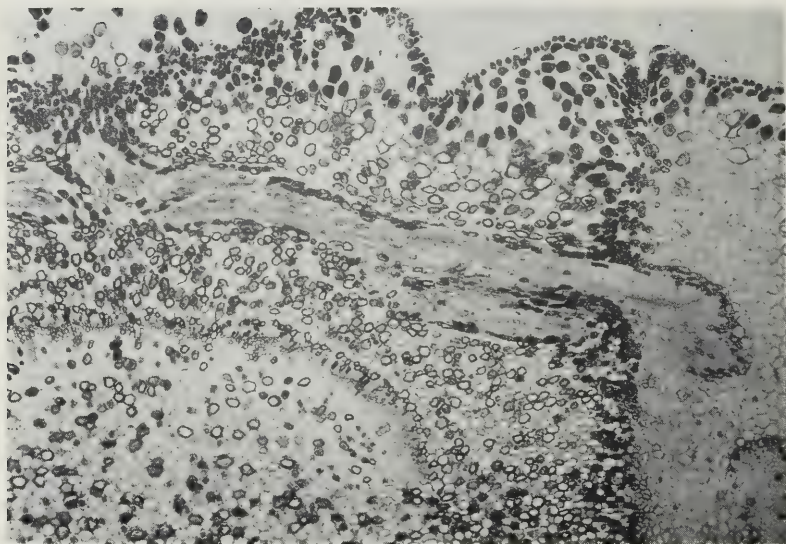


PLATE 5.

Transection through the node. Each central lateral trace diverges, the branches supplying different leaves.

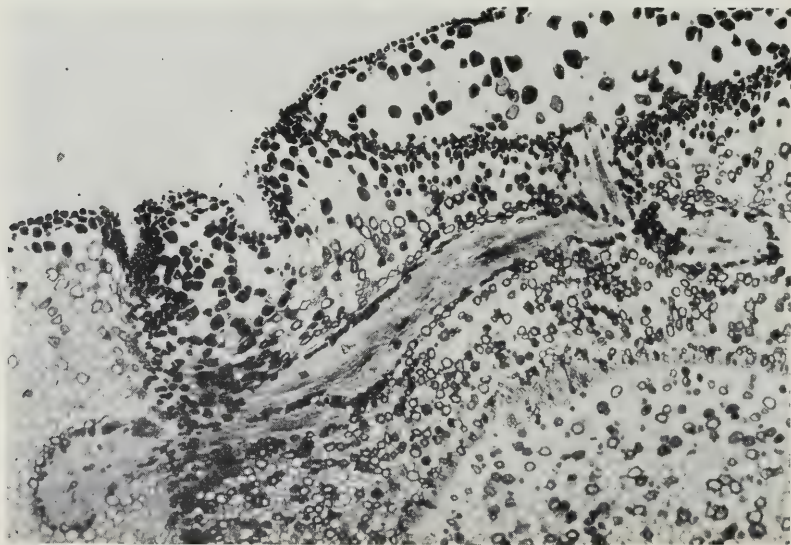


PLATE 6.

Transection through the node. Each stipule receives its marginal vascular supply from the branches of the central lateral trace.

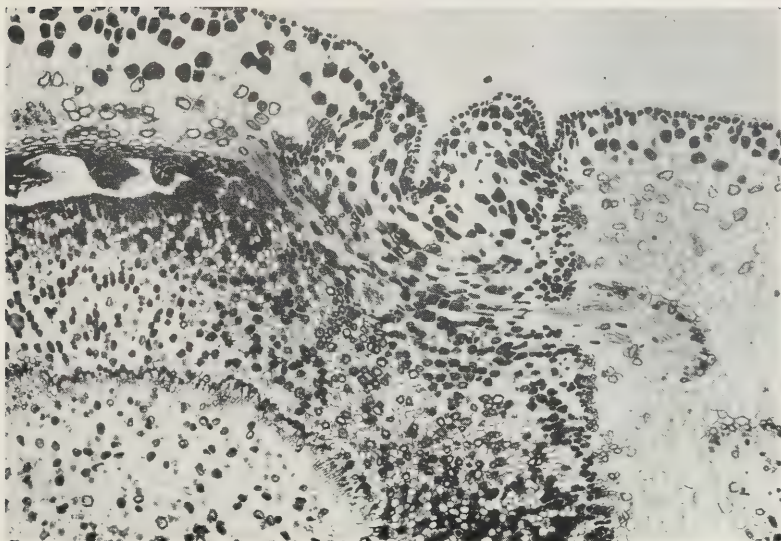


PLATE 7.

Transection through the node. The trace forming the mid-vein of the stipule arises where the central lateral trace divides.

system. The gaps are all one-trace lacunar. Each of the central lateral traces splits after departure from the cylinder and is, therefore, one-trace and not two-trace lacunar.

No reference to a nodal system of this type has been found in the literature available to the authors. Certainly, this system cannot be equated with that recorded by Sinnott (1914) as being trilacunar. However, the presence of a multilacunar system together with large stipules supports the contention of Sinnott and Bailey (1914) that, in the majority of plants with a trilacunar and presumably also a multilacunar system, stipules are present. These authors, however, state that a multilacunar condition is normally associated with plants having a sheathing base, a structure not present in *B. gymnorrhiza*. However, since the stipules are interpetiolar and inserted over a comparatively large area, the presence of a multilacunar condition is not surprising.

Sinnott (1914) reports that the Myrtiflorae are characterised by a unilacunar nodal system, and since the Rhizophoraceae were trilacunar, he contended that they should be excluded from the Myrtiflorae. This contention is supported by the present observation which demonstrates a system of nodal anatomy in the Rhizophoraceae even further removed from the unilacunar system.

Marsden and Bailey (1955) demonstrated that the unilacunar double-trace nodal arrangement was prevalent in the Pteropsida, exclusive of the Angiosperms. They suggested that this nodal condition may have been characteristic of ancestral angiosperms. Thus, the trilacunar and multilacunar arrangement would have arisen by addition of lateral traces in conjunction with the development of stipules and sheathing leaf bases. This is substantiated by the observations of Sinnott and Bailey (1914) who showed that most plants with trilacunar nodes have stipules and those with multilacunar nodes have sheathlike leaf bases.

Stipules are commonly accepted as being an integral part of the leaf because, even when they are separate appendages, they arise as outgrowths of the leaf primordia. Thus, interpetiolar stipules are considered to have arisen by fusion of adjacent stipules from opposite leaves. In *B. gymnorhiza*, therefore, the median lateral traces can be considered as having arisen by fusion of two traces. The present system, where each leaf receives five traces although there are a total of only eight gaps, must have arisen from an arrangement where there were ten gaps at each node.

#### ACKNOWLEDGEMENTS

The material used in this investigation was collected during an expedition under the leadership of Professor B. R. Allanson, Director of the Institute of Fresh Water Studies. The authors wish to thank Professor Allanson and their colleagues in the Department of Botany and Microbiology for reading and commenting on the manuscript.

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## THE GENUS SPARAXIS

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### ABSTRACT

The history of the genera *Sparaxis* and *Streptanthera* is outlined. It is proposed that *Streptanthera* be incorporated in *Sparaxis*. A taxonomic treatment follows. Six species and three subspecies are described. Of the latter, two are new combinations and one is a new subspecies. The cytology of species of *Sparaxis* and related genera is described and this is related to the taxonomy and phylogeny of the genus. The geographical distribution and hybridisation in *Sparaxis* are briefly discussed and a list of doubtful and excluded species is provided for reference.

### INTRODUCTION

The genus *Sparaxis*, a member of the family Iridaceae comprises a small group of species endemic to the South Western Cape. Although it consists of only a few species it is much in need of revision and clarification for it is very poorly understood. The existing literature and the standard references for *Sparaxis* and for *Streptanthera*, a genus which it is proposed be incorporated in *Sparaxis*, are quite inadequate as all the species have been misunderstood or misinterpreted. This is because of a lack of information in the past, particularly of a knowledge of the living plants. Owing to the confusion many specimens in herbaria are incorrectly named even according to present systems of classification. The revision may also be of value to the horticultural world, as many of the species are very attractive and are extensively cultivated in South Africa and in America and Europe, where many hybrids are now being produced. In addition to examination of living and pressed plants, a cytological investigation was undertaken to ascertain whether chromosomal studies would be of taxonomic value or reveal any relationships between this and related genera.

### MATERIALS AND METHODS

The living plants were examined both under natural conditions and in cultivation. Wherever possible large populations were studied to ascertain the range of natural variation. A large number of herbarium specimens were also examined from the following herbaria, to whose curators I wish to extend my thanks for their help:

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Accepted for publication: 27th May, 1969.



Bolus Herbarium, University of Cape Town.

Compton Herbarium, National Botanic Gardens of South Africa, Kirstenbosch.

S.A. National Herbarium, Pretoria.

Delessert Herbarium, Conservatoire et Jardin Botaniques, Geneva.

Botanischer Garten und Institut für Systematische Botanik der Universität Zürich.

Botanical Museum and Herbarium, Copenhagen.

For cytological study cells were prepared for the observation of chromosomes in the following manner. Root tips were obtained from sprouting corms, and fixed in a chrome-acetic-formalin mixture known as Craf (Randolph 1935). After fixation the tips were dehydrated through a graded ethanol-n-butanol series (Randolph 1935) and embedded in wax. They were later sectioned at 12 microns and mounted on slides. The sections were stained in Feulgen reagent, prepared by the method of Kasten & Burton (1959) and finally mounted permanently in DPX. Although only 1 karyotype is illustrated for each species involved, several drawings were made by means of a camera lucida.

#### HISTORICAL NOTE

The genus *Sparaxis* was established by Ker-Gawler in 1805 as a segregate of the genus *Ixia*. This was at that time a very large and unnatural grouping which included species of *Ixia* itself, *Romulea*, *Tritonia*, *Babiana* and *Sparaxis* amongst others. Ker-Gawler (1805) recognised 9 species of *Sparaxis*, 8 of which were previously *Ixias* and one a *Gladiolus*. In 1812 he added another species, *Sparaxis pendula*, to bring the total to 10. The main character used to distinguish the new genus was the very dry, papery and often lacerate bracts and bracteoles, and the name *Sparaxis* is derived from the Greek *sparasein* meaning torn, which alludes to the bracts.

As conceived by Ker-Gawler, the genus was still a rather unnatural assemblage which included all the plants with these characteristic bracts, although the flowers and habit of some were rather different. Some had short perianth tubes and regular or almost regular flowers, others medianly zygomorphic flowers with a long and curved perianth tube while one had an unusually long and branched, pendulous inflorescence.

Those species which had the long curved perianth tube and zygomorphic flower were separated from *Sparaxis* by Sweet (1826) and placed in a new genus *Synnotia*. This genus is recognised today as a natural group closely related to *Sparaxis* but rather more advanced due to its specialised floral characters. *Synnotia* has been revised thoroughly by Lewis (1956) and now consists of 6 species, all quite distinct from *Sparaxis*.



*Sparaxis pendula* which differed from the other members of the genus in having a long, branched pendulous inflorescence was eventually removed from *Sparaxis* and became the type of the genus *Dierama* created by Koch (1854, 1861). Subsequently many more species of *Dierama* were described and it is now known to be a rather large genus of probably more than 25 species, which extends from the Eastern Cape Province into Central Africa and Kenya. It is also a fairly natural group but has in common with *Sparaxis* the peculiar dry, papery bracts. It may be an ancestral group as it has several primitive features such as persistent corms and an evergreen habit in contrast to *Sparaxis* which has a deciduous habit and short lived corms, which are renewed annually, as the old ones disintegrate.

Ecklon (1827) listed and described several species of *Sparaxis* including a number of new species. Most of these have proved to be synonyms or to belong to *Synmotia*. However some of his epithets remain, though they now apply to subspecies.

Klatt, who worked on the Iridaceae for many years during the latter half of the 19th century described several new species, listed others and began to clarify the situation by pointing out many cases of synonymy. Some of his new species have, however, also proved to be synonyms.

Several other authors described new species of *Sparaxis* most of which proved to belong to different genera or to be hybrids and colour forms of *S. tricolor*. When Baker revised the genus in the Flora Capensis (Vol. 6 p. 115) in 1896 he recognised only four species though by this time nearly 40 species had been described or mentioned and only 10 belonged to other genera. Since the study in Flora Capensis, little has been added to the literature except for the description of one new species and one variety by L. Bolus (1932a, 1932b).

#### HISTORICAL NOTE ON STREPTANTHERA

The genus *Streptanthera* was established by Sweet (1827) when he described *S. elegans*. In 1831 he described a second species *S. cuprea* which was no more than a colour form of the earlier species. The genus was established on the rather inadequate ground that the anthers were twisted round the style and that the stigma branches were rather large. It was this twisting of the anthers that prompted Sweet to give the genus this name which means twisted flower. The other characters like the dry membranous bracts and short perianth tube are the same as in *Sparaxis*. This similarity was not however, noticed until 1867 when Klatt drew attention to it.

Klatt realised the close relationship between these two genera and he placed them after one another in his description of the Iridaceae. He must have been rather confused over the genus *Streptanthera* as he first placed *S. tricolor* in

*Sparaxis* (Klatt 1868) and then later he placed it and 3 species of *Sparaxis* in *Streptanthera* (Klatt 1882).

Unfortunately no one followed up Klatt's work and Baker who worked on the Iridaceae during the late 19th century left *Sparaxis* and *Streptanthera* distinct and ignored Klatt's work. In the Flora Capensis, Baker distinguished *Streptanthera* from *Sparaxis* on the mistaken ground that the former was actinomorphic and had a short perianth tube, while the latter was zygomorphic, due to asymmetrically disposed stamens, and had a longer perianth tube. This was in spite of the fact that two of the four species of *Sparaxis* he described, namely *S. tricolor* and *S. fragrans* are perfectly actinomorphic. He also neglected to mention the very characteristic twisted anthers in *Streptanthera*.

Baker probably did not consider the two genera as being closely related as they are placed far apart with quite unrelated genera between them in all his works on the Iridaceae. Both Marloth (1915) and Phillips (1950) persisted in distinguishing these two genera on the basis of symmetry or asymmetry of the androecium.

#### THE INCORPORATION OF STREPTANTHERA IN SPARAXIS

As has been pointed out, *Streptanthera* has been incorrectly described since Baker wrote the Iridae in the Flora Capensis. There are in fact 3 species of *Sparaxis* which have symmetrically disposed stamens and in addition have perianth tubes which are not appreciably longer than *Streptanthera*.

Thus the differences between *Sparaxis* and *Streptanthera* remain the coiling of the anthers and the size of the stigma branches of *Streptanthera*. The stigma branches are, however, constructed in the same way as in the actinomorphic *Sparaxis* species, having bilobed and expanded tips, the margins of which come together to form the stylar canal. Neither are the stamens unique, as *S. pillansii*, has anthers which are invariably twisted both in the bud and the open flower. This twist is however much less noticeable than in *Streptanthera*, but the difference here is only in degree. In all other characters especially corm tunics and bracts, which are often good generic characters in the Iridaceae, *Streptanthera* agrees very closely with *Sparaxis*. In my opinion *Streptanthera* is more closely related to *Sparaxis tricolor* and *S. pillansii* than these are to the remainder of the species of *Sparaxis* especially those with asymmetric stamens.

It is for these reasons that I propose incorporating the genus *Streptanthera* in *Sparaxis* and it is one of the purposes of this paper to clarify the confusion over the status of those plants previously known as *Streptanthera*. As I shall explain later I believe there exists only one species, not two as Sweet described, and this should now be known as *Sparaxis elegans*.

## DIAGNOSTIC CHARACTERS

*Corm*

The corm is fairly small throughout the genus, and is uniformly globose. The corms are usually 1 to 3 cm in diameter, being largest in *S. pillansii*. The tunics are usually soft and consist of a fine fibrous network, except in *S. pillansii* where they are harder and coarser. Cormlets are produced in the lower axils, at the end of the flowering season in all species. There is usually only one fairly large but narrow cormlet, up to 1 cm long, in each axil and it is sheathed by the leaves. In *S. bulbifera* many more cormlets are produced, and these occur at all the nodes. These are very much smaller, being 0·1—0·2 cm long and quite prominent when mature. This is a very characteristic feature of *S. bulbifera*.

*Stem*

The stem is strictly speaking the peduncle or scape, i.e. the leafless, or almost leafless, stalk bearing the inflorescence. The term stem has, however, been used by most workers studying this family and will thus be used for convenience sake. It is always firm and thick compared to related genera like *Ixia* and *Dierama*. It is comparatively short when compared to the rest of the vegetation amongst which it grows, being on average 30 cm high. *S. pillansii* is the tallest species and often reaches 60 cm. The height, and the number of stalks produced, varies greatly with the seasonal conditions but usually 2 or 3 are produced per corm. The stalks are simple, or branched very close to the base except in *S. bulbifera* which usually has a branch and sometimes several, borne well above the basal leaves in the axil of a cauline leaf. This character also serves to distinguish this species.

The typical spicate inflorescence may bear few to several flowers. Again, the number varies greatly with conditions, being greater when rainfall is higher and the soil good. The flowers are laxly arranged and in comparison to related genera there are few per spike. *S. pillansii* has the largest number, though this seldom exceeds 10 per spike.

*Leaves*

They are usually pale green and soft, with a silvery sheen produced by rather large epidermal papillae. The leaves vary little from the usual sword shape with a width of about 1·5 cm, being slender and longer in *S. fragrans*, and broad, short and falcate in *S. grandiflora* subspecies *violacea*. The rather characteristic leaves serve little value in recognising species. There are 5 to 12 and these vary much in shape and size with conditions.

*Bracts and Bracteoles*

As already mentioned, these structures are characteristically dry and scarious and marked with brown flecks and stripes. In *S. tricolor*, *S. pillansii* and *S.*

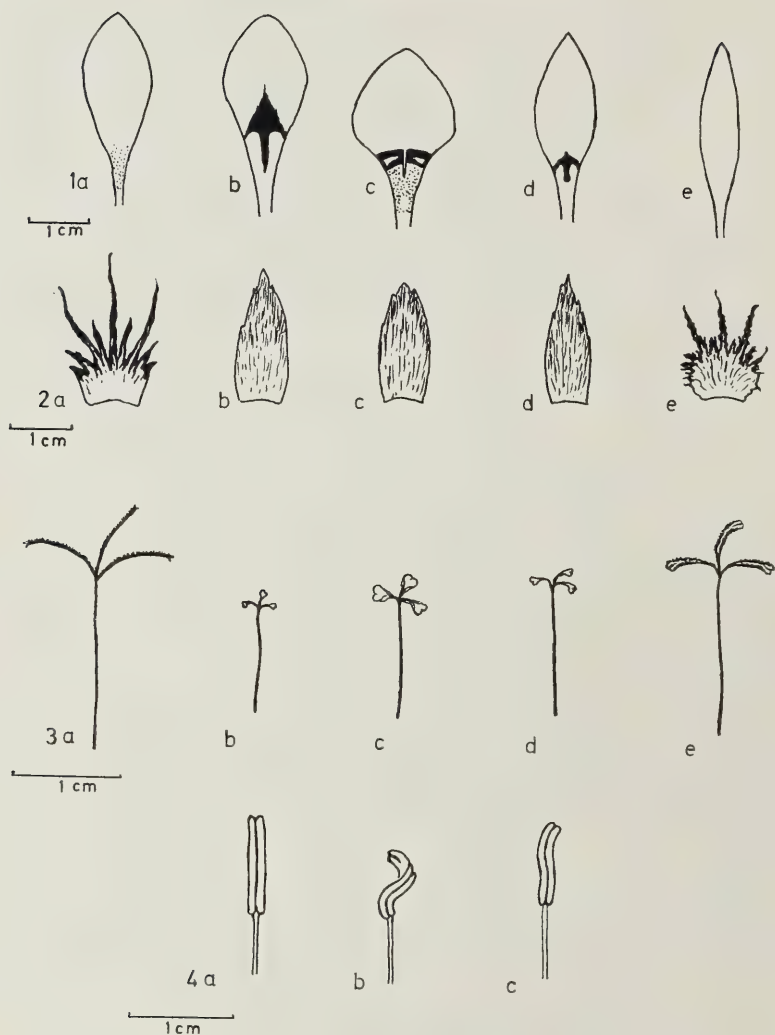


FIG. 1.

1a, 2a, 3a: perianth segment, bract and style respectively, of *Sparaxis bulbifera*. 1b, 2b, 3b, 4a: perianth segment, bract, style and stamen respectively, of *S. tricolor*. 1c, 2c, 3c, 4b: of *S. elegans*. 1d, 2d, 3d, 4c: of *S. pillansii*. 1e, 2e, 3e: perianth segment, bract and style respectively of *S. fragrans*.

*elegans* the bracts are largest, and entire or lightly lacerate. The bracteoles are also large, and marginally fused except at the tip. In the other species the bracts are smaller, being less than 2 cm long, and strongly lacerate with thin tapering cusps half the total length of the bract. The bracteoles are similar but fused only to the midline. The lacerations are very irregular and vary considerably within the same population. The lacerate bracts of *S. fragrans* are distinctive, as the long cusps are somewhat twisted and coiled, and their margins are usually irregularly serrated while in other species the cusp margins are smooth. (Fig. 1: 2a—e).

#### The Flower

Some of the species have rather dull-coloured flowers, but more often these are large and brightly coloured and marked in a striking way with geometrical patterns in contrasting colours. Frequently the nature of the patterning is very characteristic of a species. Colour and marking is usually constant in a species but occasionally colour differences occur or markings are absent. In *S. tricolor* and *S. elegans* unusually coloured or unmarked forms are known and these



PLATE 1.

Flower of *Sparaxis fragrans* showing the disposition of the stamens in an actinomorphic species.





PLATE 2.

Flower of *S. grandiflora* subsp. *acutiloba* showing the stigma and arrangement of stamens typical of the zygomorphic species.

can be regarded as mutants. In the various subspecies of *S. grandiflora* purple or white forms can predominate a population while other colours also occur and this should be regarded as a part of the variation pattern. (Fig. 1: 2.)

The perianth tube is always straight and fairly short. It is funnel shaped, consisting of a short narrow portion which is expanded upwards to form a cup. The segments are equal or sub-equal, and generally lanceolate in shape. In *S. elegans* the lobes are distinctly ovate, while in *S. grandiflora* subspecies *grandiflora* and subspecies *violacea* they are spatulate, a feature which is very characteristic. (Fig. 3: d, e.)

#### *Androecium*

The disposition of the stamens forms an important feature in the classification. The stamens are either symmetrically disposed with the anthers facing outwards or asymmetrically disposed and the anthers facing inwards. In the latter case the anterior stamen curves back to lie against the posterior perianth segment. (Pl. 2). The stamens of *S. elegans* are essentially symmetrical but due to the extreme coiling of the anthers around the style they appear asymmetrical.

The filaments are more or less as long as the anthers and the latter are unremarkable except in *S. elegans* where they are extremely coiled, and in *S. pillansii* where they are slightly so. (Fig. 1: 4.)

These features are obvious in the living plant but unfortunately almost impossible to see in dried material. Thus the clearest diagnostic feature is of questionable value in identifying dried specimens.

### *Gynoecium*

The small, oval ovary is uniform in the genus. The style, however, varies considerably in length and shape. It extends to the middle of the anthers in *S. tricolor* and *S. pillansii*, to their apices in *S. elegans* and usually beyond the anthers in *S. bulbifera*. In the remaining species it is variable, usually reaching nearly to the apices of the anthers, but sometimes beyond. The style is straight and erect in the species with symmetrical stamens. In the species with an asymmetrical androecium it is curved backwards to lie against the posterior perianth lobe behind the stamens.

The style branches also vary considerably, and form a good character for recognising some species. In the actinomorphic species, excluding *S. fragrans*, the branches are short, being less than 4 mm, with the ends expanded to form a bilobed lip behind which the margins curve upward and fold together to form a styler canal. The expanded tips of the style branches are largest in *S. elegans* and smallest in *S. tricolor*. In *S. fragrans* the branches are longer and expanded for half their length. The branches are bivalved and the upper surface is papillose. In the zygomorphic species the branches are longest being 0.8 to 1 cm long, filiform with a cleft tip and a papillose upper surface. (Fig. 1: c).

The fruits of all species are similar, being globose, three valved capsules with firm membranous walls. The seeds are comparatively large, being about 0.5 mm in diameter, smooth, round and often shiny.

### CYTOLOGICAL OBSERVATIONS

Since *Dierama*, *Ixia* and *Synnotia* have been considered closely related to *Sparaxis*, species of these genera were investigated in addition to *Sparaxis*. In all, 5 species in four genera were studied. The species and diploid number are listed below: (Fig. 2: A—E).

<i>Dierama pendulum</i>	2n = 20
<i>Ixia viridiflora</i>	2n = 20
<i>Synnotia variegata</i>	2n = 20
<i>Sparaxis elegans</i>	2n = 20
<i>S. grandiflora</i>	
subsp. <i>acutiloba</i>	2n = 20

The illustration of the chromosomes of these species shows that all share a

rather similar karyotype. The diploid number is 20, the karyotype is rather asymmetric (Stebbins 1950) and consists of fairly small chromosomes. There are two pairs of rather longer chromosomes, and the primary constrictions are sub-median or median. Owing to the small size, details are not as clear as one would wish, and the satellites are seldom clearly seen. A pair of satellite chromosomes, however seems to be present in all species.

As can be seen *Sparaxis* and *Synnotia* have rather smaller chromosomes than *Dierama* and *Ixia* but the pattern is otherwise similar.

#### KEY TO THE SPECIES

Two keys are provided. The first is a simple natural one which will be of greatest use when dealing with the living plant. The other is more complex and is designed for dried material or in a few cases for living plants which are not flowering.



FIG. 2.

Karyotypes of A. *Dierama pendula*; B. *Ixia viridiflora*; C. *Synnotia variegata*; D. *Sparaxis elegans*; E. *S. grandiflora* subsp. *acutiloba*.

## KEY 1

1. Stamens symmetrically disposed around the erect style: (This includes the case where anthers are coiled)
  2. Bracts entire or slightly lacerate
    3. Anthers erect; extending far beyond the style branches.
      4. Anthers straight; yellow..... 1 *tricolor*
      - 4'. Anthers incurved, slightly twisted; purple..... 2 *pillansii*
    - 3'. Anthers coiled; extending only to the apex of the style..... 3 *elegans*
  - 2'. Bracts deeply lacerate with cusps half as long as the bract..... 4 *fragrans*
- 1'. Stamens asymmetrically disposed, the style arched to lie behind the stamens.
  5. Stem usually branched and bearing a cauline leaf; many small Cormlets produced after flowering at all nodes;..... 5 *bulbifera*
  - 5'. Stem always simple and not bearing a cauline leaf; cormlets not produced in numbers and never exposed..... 6 *grandiflora*

## KEY 2

1. Bracts entire or slightly lacerate, more than 1 cm long.
  2. Anthers spirally coiled; perianth segments broadly ovate and obtuse..... 3 *elegans*
  - 2'. Anthers linear or slightly twisted and curved; perianth segments lanceolate or sub-ovate, acute or obtuse
    3. Plants up to 65 cm tall; up to 10 flowered; anthers red to brown; perianth segments lanceolate and acute..... 2 *pillansii*
    - 3'. Plants up to 40 cm tall; up to 5 flowered, anthers yellow to ochre; perianth segments sub-ovate and obtuse..... 1 *tricolor*
- 1'. Bracts strongly lacerate, with cusps usually as long or longer than the rest of the bract, undivided portion less than 1 cm long.
  4. Margins of cusps irregularly serrated; perianth segments less than 2.5 cm long, and less than 0.8 cm broad..... 4 *fragrans*
  - 4'. Margins of cusps entire, perianth segments usually more than 2.5 cm long, and more than 0.7 cm broad.
    5. Stem often branched and bearing a cauline leaf; many cormlets produced at all nodes on the mature plant; flowers cream or white, sometimes externally marked lightly with purple streaks and sometimes lightly spotted at the base of the perianth segments; flowers very rarely plum coloured; segments lanceolate and acute..... 5 *bulbifera*
    - 5'. Stem always simple and cauline leaf absent; few cormlets produced and at lowest nodes only; flowers variously coloured, if cream or white then strongly marked at base of segments; segments lanceolate to ovate and spatulate, and acute to obtuse.
      6. Flowers yellow or purple, perianth segments lanceolate and acute or sub-obtuse..... 6 *grandiflora*  
subsp. *acutiloba*
      - 6'. Flowers white or if purple, segments spatulate; segments lanceolate to spatulate and obtuse.
        7. Perianth segments lanceolate—ovate; cream to yellow, marked with black spots at the base..... 6b *grandiflora*  
subsp. *fimbriata*
        - 7'. Segments spatulate: white, purple or red purple.
          8. Leaves linear, sometimes slightly curved, acuminate, usually long; flowers usually uniformly deep purple; occurring in the Tulbagh area..... 6a *grandiflora*  
subsp. *grandiflora*
          - 8'. Leaves narrowly oblong to oblong, falcate with obtuse-acuminate tips; flowers not uniformly deep purple; occurring in the Caledon area..... 6c *grandiflora*  
subsp. *violacea*

## TAXONOMIC TREATMENT

## SPARAXIS

Ker. in Kon. & Sims Ann. Bot. 1: 225 (1805) et Gen. Irid. 94 (1827); Ecklon, Top. Verz.: 27 (1827); Klatt in Linnaea 32: 747 (1863) et Erganz.: 56 (1882); Baker in Journ. Linn. Soc. Bot. 16: 99 (1878); Benth. & Hook., Gen. Pl. 3: 708 (1883); Pax in Engl. & Prantl. Pflanzenf. 11, 5: 155 (1889); Baker, Handbk. Irid.: 198 (1892) et Fl. Cap. 6: 115 (1896); Marloth, Fl. S.A. 4: 148 (1915); Diels in Engl. & Prantl. Pflanzenf. ed. ii. 15a: 491 (1930); Lewis in Adamson & Salter, Fl. Cap. Pen.: 245 (1950); Phillips, Gen. S.A. Pl. ed. ii: 281 (1951).

STREPTANTHERA Sweet in Br. Fl. Gard. ser. i. t. 127 (1827) Klatt, Erganz.: 56 (1882); Benth. & Hook., Gen. Pl. 3: 703 (1883); Pax in Engl. & Prantl. Pflanzenf., 2, 5: 154 (1889); Baker, Fl. Cap. 6: 86 (1896); Phillips, Gen. S.A. Pl. ed. ii: 218 (1951).

BELEMCANDA Moench, Meth. Suppl.: 214 (1802).

IXIA L. Amoen. Acad. 4: 300 (1756) pro parte sole *I. bulbifera*.

*Corm* small, globose with tunics of fine to moderately fine fibres. *Stem* firm, semi-erect or erect, glabrous, simple or branched or bearing a cauline leaf, with a few large cormlets in the lower axils or many small cormlets in all axils. *Leaves* acute, acuminate or obtuse-acuminate, glabrous and closely ribbed with the midrib distinct. *Spike* few to several flowered, occasionally solitary, lax, flowers arranged distichously in bud, alternate or secund when blooming. *Bract* larger dry scarious and fringed and streaked with brown markings, deeply lacerate with long tapering cusps or entire or lightly lacerated; *bracteoles* similar, smaller, fused to the middle or almost to the top. *Flowers* large, actinomorphic or zygomorphic; *perianth tube* short, cylindrical at base, expanded upwards; *perianth* segments equal or sub-equal, lanceolate to ovate or spatulate, acute to obtuse. *Stamens* arising from the base of the expanded part (throat) of the perianth tube, symmetrically or asymmetrically disposed; *filaments* filiform, straight or curved, contiguous or free, about as long as the anthers; *anthers* straight, curved or spirally coiled, basifixed just above the base, facing outwards or inwards, loculi opening from base to apex. *Ovary*, ovoid; *style* extending to the middle, top or beyond the anthers, straight and erect or curved; *branches* 3, short with expanded tips or long and filiform with the upper surface papillose. *Capsules* small, globose and firm—membranous; *seeds* several, large smooth, rounded and often shiny.

Type species. *S. bulbifera* (L) Ker.

1. *S. tricolor* (Schneevogt) Ker. in Kon. & Sims Ann. Bot. 1: 225 (1805) et Gen. Irid.: 93 (1827); Ait., Hort. Kew ed. ii. 1: 85 (1810); Klatt in Linnaea 32: 747



(1863); Baker in J. Linn. Soc. Bot. 16: 98 (1878), Handbk. Irid.: 197 (1892), et Fl. Cap. 6: 117 (1896); Marloth, Fl. S.A. 4: 148 (1915). *Ixia tricolor* Schneevogt, Icon. Pl. Rar.: t. 39 (1795); Ker. in Bot. Mag. t. 381 (1797); Vahl, Enum. Pl. 2: 74 (1804); D.C. in Red., Lil.: t. 129 (1807). *Streptanthera tricolor* (Sweet) Klatt, Erganz. 56 (1882).—Iconotype: Schneev. 1c. Pl. Rar. t. 39.

*Corm* globose, 1—2 cm in diameter with tunics of fairly fine silky, white fibres. *Stem*, simple, erect or semi-erect, firm usually 30 cm (10 to 40 cm) high, 1—5 in number, bearing a few small cormlets at the lower nodes. *Leaves*, 5—10 distichous, arranged as a fan, generally 1—2 cm broad, ensiform, acute, acuminate, usually long but never reaching beyond the lowest flowers, glabrous, closely veined with a prominent midrib. *Spike* lax, 2—5 flowered. *Bract*, dry, scarious marked with brown flecks, lightly lacerate at the tip or entire, 2·5—3·0 cm long; actinomorphic; *bracteoles* similar but shorter, 2·0—2·5 cm, bifid. *Flowers* actinomorphic, brightly coloured and patterned; *Perianth tube* about ·8 cm long, narrow portion ·2—·3 cm long, yellow; *perianth segments* subequal, broadly lanceolate, acute, 2·5—3·3 cm long and about 1 cm broad, vermilion or salmon, marked with a black to red sagittate marking at the base (rarely unmarked); *Stamens* symmetrically disposed; filaments 6—7 mm long, yellow, linear, contiguous, inserted at the base of the broad part of the perianth tube; *anthers* 8—9 mm long, linear, white or yellow, basifixed just above the base, cells facing outwards. *Ovary* small, ovoid, *style* yellow, comparatively short, not reaching to the middle of the anthers; *branches* 0·1—0·2 cm long and slightly expanded and bilobed at the tips. *Capsules* globose, firmly membranous; *seeds* several, large, smooth and round. *Chromosome number*  $2n = 20$ .

Clay flats and damp places north west of Nieuwoudtville usually occurring in renosterbosveld (Acocks 1952).

Flowering time: September.

*Incones*: Schneev. 1c. Pl. Rar. t. 39 (1795) as *Ixia tricolor*; Ker in Bot. Mag. t. 381 (1797) as *I. tricolor* and t. 1482 as *S. tricolor*; Redoute, Lil. t. 129 (1807) as *I. tricolor*; Marloth, Fl. S. Afr. 4, fig. 40.

CAPE.—3119 (Calvinia): 10 miles from Nieuwoudtville on Grasberg road. (—AC), *Barker 9541* (NBG); Grasberg, *Barker 9551* (NBG); Grasberg road north west of Nieuwoudtville, *Goldblatt 348* (BOL); vlei near Nieuwoudtville, *Leipoldt 280* (BOL).

WITHOUT LOCALITY: *Ecklon & Zeyher 111* (SAM).

LOCALITY DOUBTFUL: Tulbagh, *Ecklon s.n.* (PRE 30490); Tulbagh, *Pappe s.n.* (SAM 21314).

This attractive species is endemic to a very small area. It is found in a shallow valley, north west of Nieuwoudtville at a distance of 4 miles from the town, extending a further 7 miles. In apparently undisturbed ground the plants occur amongst rhenosterbos and are thus lightly shaded. The soil type is invariably a heavy clay which is waterlogged for part of the growing season, though it eventually dries to an almost cement-like consistency.

With regard to flower colour, two shades of orange occur in nature, a vermilion and a paler creamy-orange shade. The markings are very much the same in most plants but rarely, plain orange unmarked forms can be found.

The species has an uncomplicated taxonomy and has apparently never been described under another epithet since it was named by Schneevogt. However a large number of hybrids and colour forms have been ascribed to this species. As is well known, species of *Sparaxis* are all interfertile and hybrids are easily produced (Horn 1962; L. Bolus 1932). In view of this it is perhaps fortunate that no more hybrids have been described. These putative hybrids including *S. blanda* Sweet, *S. griffini* Sweet, *S. versicolor* Sweet and *S. stellata* Roem. & Schultes. are discussed in a later section.

The flowers of *S. tricolor* have such characteristic markings that the species should never be misidentified. It has been placed at the beginning of the present treatment as it is clearly the least specialised with its symmetrically disposed stamens, straight anthers, erect style and short perianth tube.

2. ***S. pillansii*** L. Bolus in S.A. Gard. 22: 57 (1932).—Holotype: *L. Bolus s.n.* in the Bolus Herbarium (BOL 19182).

*Corm* globose, from 1—3 cm in diameter, tunics of moderately fine, brown rather hard fibres. *Stem* firm, glabrous, erect, simple, 25—65 cm high, 2—4 in number, bearing small cormlets in the lower axils. *Leaves* 8—10, distichous narrow, ensiform, up to 35 cm long, not reaching the lowest flowers, only lightly ribbed. *Spike* 4—9 flowered, lax. *Bract* large, 2.5—2.9 cm long, dry, scarious with red-brown streaks, lightly lacerate at the apex; *bracteoles* similar, fused almost to the tip, smaller. *Flowers* brightly coloured and marked, actinomorphic; *perianth tube* yellow, 0.7—0.9 cm long, the narrow portion 0.2—0.3 cm long; *perianth segments* old rose, marked at the base with a heart shaped yellow portion extending into the perianth tube and separated by a narrow purple band from the rose coloured part, subequal, lanceolate and broadly sub-acute, 2.2—2.9 cm long, 1.0—1.3 cm wide. *Stamens* symmetrically disposed; *filaments* white, linear, contiguous at the base, 0.7—0.8 cm long, inserted in the throat of the perianth tube; *anthers* purple red, slightly longer than filaments, basifixed, incurved and slightly twisted at the tip, cells facing outwards. *Ovary* small, ovoid; *style* white with red above, erect reaching to the

middle of the anthers; *branches* red maroon, 0·3 cm long expanded at the tip, bilobed, extending between the anthers. *Capsule* globose, firmly membranous; *seeds* several, fairly small, round and smooth. *Chromosome number* unknown.

Rocky hills north of Nieuwoudtville, among boulders in heavy red clay which remains waterlogged for much of the growing period. Also recorded from the farm Driefontein, south west of Calvinia.

Flowering time: September.

CAPE.—3119 (Calvinia): Klipkoppies Nieuwoudtville (—AC), *Barker* 9530 (NBG), *Lewis* 5856 (NBG); near Nieuwoudtville *L. Bolus* s.n. (BOL 19182); Charles Hoek north east of Nieuwoudtville, *Goldblatt* 327 (BOL); Rooikoppies east of Nieuwoudtville, *Marloth* 7937, 7949 (PRE); Near Nieuwoudtville, *Metelerkamp* s.n. (BOL 19182); Driefontein south west of Calvinia (—CA), *Marloth* 10428 (PRE).

This is the tallest of all the species of *Sparaxis*. It is not so brightly coloured as *S. tricolor* nor so strikingly marked as *S. elegans* but its red colour and markings are quite distinctive. It hybridises easily with *S. tricolor* and is one of the parents of several garden forms now grown.

To the author's knowledge, this species remained unknown until 1915 when it was collected by Marloth. Later it was cultivated by specialists who at first thought it a garden hybrid. In 1930 it was rediscovered in the wild and was described by L. Bolus in 1932.

The plant has a rather peculiar, very localised habitat about which more should be said. It occurs over a few acres on the rocky hills a mile north east of Nieuwoudtville, where it is plentiful. It grows in red clay around large boulders where water accumulates in quantity during the short wet season and is semi-aquatic during the early stages of growth. It has also been recorded by Marloth from the farm Driefontein, south west of Calvinia, but this requires confirmation.

*S. pillansii* is closely related to *S. tricolor* in having very similar, though somewhat smaller markings, symmetrical and erect stamens and a very similar style, but it is quite easily distinguished because of its height, colour and the slight twist of the anthers.

### 3. *S. elegans* (Sweet) Goldblatt. comb. nov.

*Streptanthera elegans* Sweet, Br. Fl. Gard. ser. 1: t. 209 (1827) et Hort. Brit. ed 11: 501 (1830). Basionym; Lodd., Bot. Cab.: t. 1359 (1827); Klatt, *Erganz.*: 56 (1882); Baker in J. Linn. Soc. Bot. 16: 92 (1878), *Handbk. Irid.*: 160 (1892) et Fl.: Cap.: 86 (1896).—Iconotype: Brit. Fl. Gard.: t. 209. *S. cuprea* Sweet, Br. Fl. Gard. ser. 2: t. 122 (1831) et Hort. Brit. ed. ii: 501 (1830); Paxt., *Mag. Bot.* 1: 893 (1878), *Handbk. Irid.*: 160 (1892) et Fl. Cap. 6: 86 (1896); Pole-Evans

in Fl. Pl. S. Africa 8: pl. 320 (1928). *Sparaxis cuprea* (Sweet) Klatt in Linnaea 35: 378 (1868).—Iconotype: Br. Fl. Gard. ser. ii: t. 122 *Streptanthera cuprea* var *non-picta* L. Bolus. S.A. Gard. 32: 276 (1932).—Holotype: Buhr s.n. (BOL 19443).

*Corm* globose, 1.0 to 1.7 cm in diam, with tunics of moderately fine, white fibres. *Stem* semi-erect short, 10–30 cm long, simple, firm, 2–5 in number, bearing a few small elongated cormlets at the lowest nodes. *Leaves* 5–9, distichous, arranged as a fan shape, ensiform, acuminate, glabrous, closely veined, midrib prominent, lower leaves sometimes curved, 0.5 to 1.4 cm broad, 8–25 cm long. *Spike* 1–5 flowered. *Bract* 2.2 cm long; *bracteoles* similar but smaller, 1.6–2.0 cm long, apex bifid. *Flowers*, actinomorphic, brightly coloured and patterned; *perianth tube* yellow 0.6–0.8 cm, narrow portion short, 0.15 to 0.2 cm *perianth segments* sub-equal, ovate and obtuse, 1.8–2.2 cm long and 1.4–1.7 cm broad, vermilion fading to pink, rarely white, base marked internally with a violet band, with or without 2 yellow streaks at the edges of the band, rarely unpatterned. *Stamens* symmetrically disposed; *filaments* yellow; 0.5–0.6 cm long, inserted at the base of the narrow part of the perianth tube, *anthers* maroon to brown, shorter than filaments, .04–0.4 cm high, not linear but coiled in a spiral round the style. *Ovary* small, ovoid; *style* yellow but red at the top, reaching to the top of the anthers, *branches* short, about 2 mm long, the tips forming a bilobed and expanded lip, behind which the margins curve upwards and meet to form a styler canal. *Capsules* globose; *seeds* comparatively large, round and smooth. *Chromosome number*  $2n = 20$ .

Clay hills and flats around Nieuwoudtville.

Flowering time: September.

*Icones*: Sweet in Br. Fl. Gard. ser. i: t. 209 (1827) as *Streptanthera elegans* and Br. Fl. Gard. ser. ii: t. 122 (1831) as *S. cuprea*; Lodd., Bot. Cab. t. 1359 (1827) as *S. cuprea*; Letty in Fl. P.S. Afr. pl. 320 (1928) as *S. cuprea*.

CAPE—3119 (Calvinia) Glenlyon farm (—AC), *Acocks* 19025 (PRE), *Goldblatt* 350 (BOL), *Lewis* 5909 (NBG), Klipkoppies slopes, *Barker* 9536 (NBG); Nieuwoudtville, *L. Bolus* s.n. (BOL 19588), *Buhr* s.n. (NBG 60957) and (BOL 19443), *Loubser* 946 (NBG), south of Nieuwoudtville, *Goldblatt* 102 (J); Willemsrivier 1.5 miles north Nieuwoudtville, *Goldblatt* 349 (BOL); Willemsrivier, *Leipoldt* 218 (SAM); Oorlogskloofrivier, *Leipoldt* 799 (BOL, SAM); east of Nieuwoudtville, *Marloth* 9647 (PRE).

This species is quite unmistakable as it is so strikingly marked with salmon-pink and contrasting brilliant violet and has dark purple, coiled anthers. In



populations south of Nieuwoudtville the violet band has two bright yellow spots in it, which give the effect of a remarkable geometric pattern. The species is not as localised as *S. tricolor* and *S. pillansii* and its range extends from 2 miles north of Nieuwoudtville and almost 10 miles southwards. It is extremely common in this area on clay and decomposing shale.

This species was previously known as *Streptanthera*, a genus comprising of two separate species and a variety. The species differed only in their colouring, *S. elegans* Sweet having white perianth segments and *S. cuprea* Sweet having salmon segments, while the variety had unmarked salmon coloured flowers. As previously mentioned, mutant forms do occur rarely, and both the white form and the unmarked one are examples of these. The author has seen many thousands of individuals of *Sparaxis elegans* and *S. tricolor* and observed only one mutant, an unmarked *S. tricolor*. It is perhaps unfortunate that *Sparaxis elegans* must be based on the description of the unusual white flowered form, but this epithet has priority over that of *Streptanthera cuprea*, the common form.

4. *S. fragrans* (Jacq.) Ker. in Kon. & Sims. Ann. Bot. 1: 225 (1805). et Gen. Irid.: 93 (1827); Baker, Fl. Cap. 6: 117 (1895); Klatt, Erganz.: 55 (1882). *Ixia fragrans* Jacq., Ic. Pl.: t. 274 (1793); Willd, L. Sp. Pl. 1: 197 (1798); Pers. Syn. Pl. 1: 47 (1805).—Iconotype: Jacq. Ic. Pl. t. 274; *I. sordida* Hornem., Hort. Hafn. Suppl. 6 (1819).—Holotype: Horneman s.n., (C) *Gladiolus odoratus* Schrank, Denks. Bot. Ges. Regensb. 2: 206 (1822) non Salisb. (1796). nom illegit.—Iconotype: Jacq. Ic. Pl.: t. 274.

*Corm* globose, 0.8—1.5 cm in diameter, tunics of fine fibres extending upwards in a neck. *Stem* firm, glabrous, erect, simple, 7—30 cm long, 1 or 2 in number and bearing a few cormlets in the lowest axils. *Leaves* 6—10, distichous, linear-ensiform and acute, usually narrow but from 0.2—0.9 cm broad, and from 5—20 long, the lower being shorter and recurved. *Spike* lax, 1—2 flowered but occasionally up to 5 flowers. *Bract* dry, firm, scarious marked with brown streaks, deeply lacerate, apices forming long cusps, usually 3 in number, twisted, coiled, and irregularly serrated; *bracteoles* similar and smaller with 2 cusps. *Flowers* actinomorphic, bright or dull coloured, seldom marked and having a rather unpleasant odour; *perianth tube* yellow, 0.6—0.8 cm long, the narrow portion up to 0.4 cm long; *perianth* segments yellow, cream or beige, occasionally marked at the base with two small dark spots, sometimes marked externally with purple or brown streaks down the centre, subequal, lanceolate, acute, occasionally retuse, 1.8—2.5 cm long, about 0.7 cm wide; *Stamens* symmetrically disposed; *filaments* yellow, about 6—9 mm, long, linear, facing outwards. *Ovary* small, ovoid; *style* yellow linear, erect reaching nearly to the top of the anthers; *branches* about 0.5 cm long, curved, expanded for



half the length, lying between the anthers. *Capsule* small, globose and firm-membranous; *seeds* small, round and smooth. *Chromosome number* unknown.

Damp clay flats and banks in the Caledon and Bot river areas.

Flowering time: August to September.

*Icones*: Jacquin, 1c. Pl.: t. 274 (1793) as *Ixia fragrans*.

CAPE—3419 (Caledon): near Bot River (—AA), *Barnard s.n.* (BOL 29566); 1 mile north of Bot River, *Goldblatt 290* (BOL); 10 miles north of Bot River, *Goldblatt 296* (BOL); 1 mile along Langhoogte road, *Goldblatt 299* (BOL); between Bot River and Goedvertrou, *Rourke 1091* (NBG); 1 mile on Caledon road past Villiersdorp turnoff (—AB), *Barker 4* (BOL); Caledon-Villiersdorp road, *Barker 5* (BOL); Caledon-Villiersdorp road, *Barnard s.n.* (BOL 29564); Zwart Berg, Caledon, *Ecklon and Zeyher 118* (SAM, PRE, Z); 4 miles east Caledon near Main road, *Goldblatt 342* (BOL); Diep Rivier, *Martley s.n.* (BOL 29565).

This rather small-flowered species, which often has very slender leaves, was described and figured by Jacquin at the end of the 18th century. Though it was subsequently mentioned by other authors and duly placed in *Sparaxis* by Ker-Gawler it remained rather poorly known, and its existence was doubted by Baker (1896). It was collected during the 19th century by Ecklon and Zeyher, and Horneman described the plant as *S. sordida*.

The species was collected at infrequent intervals during the last 30 years but not recognised as *S. fragrans* except by T. Barnard. Recent investigation has shown that it is very common on clay slopes and flats in the Bot River Valley and along the Caledon Road. It is quite distinct from *S. bulbifera* and *S. grandiflora*, though the bracts are similar. Its small flower, unmistakable odour and symmetrically disposed stamens distinguish it sharply from these last mentioned species.

*S. fragrans* is intermediate between the actinomorphic and zygomorphic flowered species. Its bracts and bracteoles are very like the lacerate type of *S. bulbifera* and *S. grandiflora* though they differ in having serrate margins. The style is intermediate in length as it extends to the apex of the anthers, and has long branches, although the ends are expanded as in the actinomorphic species. The symmetrical stamens point to a close relationship with *S. tricolor*.

5. *S. bulbifera* (L.) Ker. in Kon. & Sims. Ann. Bot. 1: 225 (1805) et Gen. Irid.: 94 (1827); Aiton, Hort. Kew. ed ii. 1: 86 (1807) pro parte excl. plantae florum luteorum; Klatt in Linnaea 32: 748 (1867) pro parte excl. plantae florum

luteorum; Baker in Linn. Soc. Bot. 16: 98 (1878) pro parte excl. var *flava* Thunb. ined.; Baker, Handbk. Irid.: 197 (1892) pro parte excl. var *violacea* Ecklon et plantae florum luteorum. *Belamcanda bulbifera* (L.) Moench, Method. Suppl.: 214 (1802). *Ixia bulbifera* L. Amoen. Acad.: 300 (1756); Miller, Dict. ed. 8: *Ixia* 6 (1768) et Icon.: pl. 236, f.2 (1760); Lam., Encyc. 3: 339 (1789); Burmann, Prod. Fl. Cap.: 1 (1768) Thunb., Dissert. de *Ixia*: 474 (1799) pro parte excl. vars. *flava*, *purpurea*, *rubra-albaque*; Willd., in Linn. Sp. Pl. 1: 204 (1798); D.C. in Red., Lil.: t. 128 (1827).—Neotype: *Linnaeus* 58/16 in Linn. Herb. *I. anemonaeflora* D.C. in Red., Lil.: t. 85 ( $\pm$ 1804) non Jacq. (1793).—Iconotype: Red. Lil.: t. 85 *Sparaxis albiflora* Ecklon, Top. Verz.: 28 (1827)—Lectotype: *Zeyher* s.n. (SAM).

*Corm* small, globose, 0.9—1.6 cm in diameter, tunics of fine white fibres. *Stem* firm, glabrous, erect, usually branched once, but occasionally up to 3 times, 15—50 cm tall, bearing many small cormlets in the axils of all the leaves including the cauline leaves subtending the branches, cormlets appearing only after flowering. *Leaves* 5—9, distichous, ensiform, acute or acuminate, 0.4—1.0 cm broad, rarely reaching as high as the lowest flowers, densely ribbed with the midrib distinct. *Spike* lax, 1—4-flowered or occasionally up to 6-flowered. *Bract* dry, firm, scarious, marked with brown streaks near the margin, deeply lacerate, apices forming 1—3 long cusps which are straight or slightly twisted and entire; *bracteoles* similar, smaller and usually 2-cusped. *Flowers* zygomorphic, and cream coloured; *perianth tube* yellow but lower portion green externally, 1.4—1.6 cm long, the narrow portion 0.5—0.7 cm; *perianth segments* cream to white internally, rarely black-dotted at the base, the outside similar or frequently broadly streaked down the centre with purple, (segments rarely uniformly plum coloured), lanceolate, subacute, 2.5—2.8 cm. long, about 1.2 cm broad. *Stamens* asymmetrically disposed, the anterior stamen recurved to lie against the posterior perianth segment; *filaments* white, curved, 0.7—0.8 cm long; *anthers* white, facing inwards and slightly curved, basifixed, 0.7—0.8 cm long. *Ovary* small, ovoid; *style* white, usually reaching beyond the top of the anthers, curved and lying behind the stamens against the posterior perianth segment; *branches* white, filiform and curved, about 1 cm long. *Capsule* small, globose, firmly membranous; *seeds* fairly numerous, round. *Chromosome number* unknown.

Flats or lower slopes of hills and mountains. Most frequently in sandy ground which is very wet during winter. Also on clay or hill slopes.

Flowering time: August to October.

*Icones*: Miller. Ic. Pl. t. 236 fig. 2 (1760) as *Ixia* sp.

CAPE—3318 (Cape Town): between Bokbaai and Darling (—AC), *Esterhuysen* 4375 (BOL); Darling sandy places, *Grant* 2538 (BOL); Malmesbury (—BD), *Compton* 9374 (NBG); Paardeberg Paarl (—CA); *Salter* 7665 (BOL); Kalbaskraal, *Weiderman and Oberdieck* 300 (PRE); Wellington (—CB), *Thomson s.n.* (PRE 30489). Muldersvlei (—CC), *Lewis* 4431 (SAM); Ysterplaat airport, west boundary (—CD), *Goldblatt* 262 (BOL); Tygerberg, *Henry s.n.* (NBG 63052); Kraaifontein, *Hubbard* 243 (BOL); Welgemoed, Bellville, *Loubser* 2111 (BOL); Mamre, *Cassidy* 252 (NBG); Mamre hills, *Compton* 11607 (NBG) *Wasserfal* 1010 (PRE); Ganzekraal vlei, *Goldblatt* 305 (BOL); Kenilworth (—DC), *H. Bolus* 8021 (BOL, PRE); Milnerton, *Cassidy* 254 (NBG); Llandudno, *Compton* 1482 (NBG); Mowbray, *Marloth* 7169 (PRE); Cape Town, *Pappe s.n.* (SAM 48515); Green point, *Pappe s.n.* (SAM 21316), Zeyher s.n. (PRE 30484, Z); Cape Flats, *Schlechter* 1558 (Z).

—3319 (Worcester): Worcester (—DB), *Walters* 194 (NBG).

—3418 (Simonstown): Oatlands point (—AB), *Wolley-Dod* 2855 (PRE); Sandy flats near Gordons Bay (—BB), *Parker* 4239 (NBG).

—3419 (Caledon): 9 miles west Bot river (—AA), *Goldblatt* 330 (BOL); west of Caledon, *Goldblatt* 331 (BOL); Mossel river shore, Hermanus (—AC), *Compton* 2362 (NBG); Klein river mountains, *Stokoe s.n.* (SAM 65861); Stanford, Klein river mountains, *Stokoe* 6167 (BOL); Hermanus near Hawston (—AD), *Goldblatt* 329 (BOL); Hermanus camp, *Lussem* 10 (NBG); Ratel river near homestead (—CA), *Goldblatt* 335 (BOL); Dirk Uyskraal farmhouse, *Goldblatt* 331 (BOL); west of Elim, *Muir* 5020 (NBG).

—3420 (Bredasdorp): Bredasdorp (—DA), v. *Breda* 713 (PRE).

There is some doubt that specimen 58/16 in the Linnaean Herbarium is the type of *Sparaxis bulbifera*.

In the description (Centuria 2, 1756) Miller is mentioned as having provided the specimen or corms, which are believed to have reached Linnaeus in 1755. The specimen in the Linnaean Herbarium is not credited to Miller, but has the inscription "H.U." indicating that the plant was grown at Uppsala. As it was Linnaeus' habit to endorse specimens on the back with the name of the sender, it seems Linn. Herb. 58/16 was probably not provided by Miller. This specimen was probably made after 1756 and identified by Linnaeus as *Ixia bulbifera*. It matches the description of *I. bulbifera* though not perfectly. For example, the corm is described but the specimen does not have one. In addition, it is mentioned that there are two to three flowers per stem while specimen 58/16 has only two. Thus Linnaeus must have seen several specimens. There can, however, be no doubt of the identity of the species as it is the only *Sparaxis* in which the production of cormlets is distinctive and the colour description: *flavescenti-albida fundo flavo*, (i.e. cream with a yellow base) is unique to *S. bulbifera*. Therefore

it is proposed that the specimen in the Linnaean Herbarium is considered as a neotype.

Although this species is quite distinct, it is often difficult to recognise until it has almost finished flowering. This is because the branches are often concealed at the early stages, and the cormlets do not form until after flowering. The species can be distinguished from the other white-flowered forms on less obvious points; it differs from *S. grandiflora* subspecies *fimbriata* in having subacute perianth segments and none or only small dark spots at the base of the segments; from subsp. *violacea* (white form) as the latter has spatulate perianth segments.

This is the most widespread of the species of *Sparaxis*. It is found from Picketberg in the north, through the Malmesbury and Cape Town districts and east to Caledon and Bredasdorp, with a single record from the Worcester area. It has the widest ecological tolerance, as it occurs on sand as frequently as on clay, and grows in vleis or somewhat drier areas, on flats and lower slopes of mountains.

Although *S. bulbifera* has a fairly uncomplicated taxonomy, it has been confused with *S. grandiflora* since the former was described. Thunberg in his Dissert. de *Ixia* included in the species, white, yellow and purple flowered forms which we know now to be distinct species. *S. grandiflora* subsp. *fimbriata* has frequently been included in *S. bulbifera* or vice versa and even Lewis (1950) failed to realise these were two different species.

It has also long been confused with *S. grandiflora* subsp. *acutiloba* and it appears that Ker-Gawler thought that this yellow flowered form was in fact *S. bulbifera*. (Bot. Mag. t. 545). This yellow flowered form from the Olifants River valley has been misidentified as *S. bulbifera* since Baker (1878), but the stems never branch nor does it produce numerous cormlets, and *S. bulbifera* itself never has yellow flowers.

6. *S. grandiflora* (da La Roche) Ker., in Kon. & Sims Ann. Bot. 1: 225 (1804) et Gen. Irid.: 94 (1827); Ecklon, Top. Verz.: 27 (1827); Klatt in Linnaea 32: 748 (1863); Baker in Linn. Soc. Bot. 16: 98 (1878) pro parte excl. var *stellaris* Sweet et var *lineata* Sweet; Bak., Handbk. Irid.: 197 (1892) et Fl. Cap. 6: 116 (1896); Marloth, Fl. S. Africa 4: 148 (1915) pro parte excl. var *liliago*; Lewis in Adamson & Salter, Fl. Cap. Pen.: 245 (1950) pro parte excl. plantae florum maculatum. *Ixia grandiflora* de La Roche, Dissert. Descript. Pl. Nov.: 23 (1766); Burmann, Prod. Fl. Cap.: 1 (1768); Ker. in Bot. Mag.: t. 541 (1804); D.C. in Red. Lil.: t. 362 (1813).—Neotype: Goldblatt 303 (BOL) *I. uniflora* L., Mant.: 27 (1770); Houtt., Nat. Hist. 12: 22 (1780); Jacq. Ic. Pl.: t. 238 (1793).—Holotype: Lin. Herb. 58/19. "*I. aristata*" sensu Ait., Hort. Kew ed. ii. 1: 57 (1789) non Thunb. (1783); Willd., Sp. Pl. 1: 203 (1798); Pers., Syn. Pl. 1: 47 (1805); *I. aristata* var *atropurpurea* Ker. in Andr., Bot. Rep. 2: t. 87 (1797). *Belemcanda aristata* (Ait.) Moench, Meth. Suppl.: 214 (1802). *Ixia holosericea* Jacq., Hort. Schoen.: t. 17



(1797).—Iconotype: Jacq. Hort. Schoen.: t. 17. *Sparaxis atropurpurea* Klatt, Erganz.: 55 (1882).—Lectotype: Zeyher 516 (LUB).

*Corm*, globose, 0.6–1.5 cm in diameter, tunics of fine white fibres. *Stem* firm, glabrous, erect, simple 8–45 cm high, 1, 2 or occasionally 3 in number, bearing a few cormlets in the lowest axils only. *Leaves* 6–10, distichous, ensiform, lanceolate or falcate, 0.4–1.3 cm broad, usually fairly short but from 3–30 cm long, acute, acuminate, or obtuse acuminate. *Spike* lax 1–6 flowered. *Bracts* dry, firm, scarious, usually marked with brown streaks especially on margin, rarely uniformly white, deeply lacerated, apices forming 1–3 long cusps which are straight or slightly twisted and entire; *bracteoles* similar but smaller, 2-cusped. *Flowers* zygomorphic, dull or brightly coloured, either marked or not; *perianth tube* yellow, purple or black, 1.0–1.4 cm long, the narrow portion 0.3–0.5 cm long; *perianth segments* uniformly cream coloured or marked with black blotches at the base or marked externally with broad purple stripes, or uniformly red-purple, violet-purple or yellow with or without dark spots and or streaks, lanceolate to ovate, or spatulate, sub-acute or obtuse, 2.4–3.0 cm long, 1.2–1.6 cm broad. *Stamens* white or yellow, asymmetrically disposed, the anterior stamen recurved to lie against the posterior segment; *filaments* curved, 0.7–0.9 cm long, *anthers* facing inwards and slightly curved, somewhat longer than the filaments. *Ovary* ovoid; *style* white or yellow, usually reaching almost to the apex of the anther, recurved and lying behind the stamens against the posterior perianth lobe; *branches* filiform, curved and from 0.6–1.0 cm long. *Capsule* small, globose, firmly membranous; *seeds* fairly numerous and round. *Chromosome number*  $2n = 20$ .

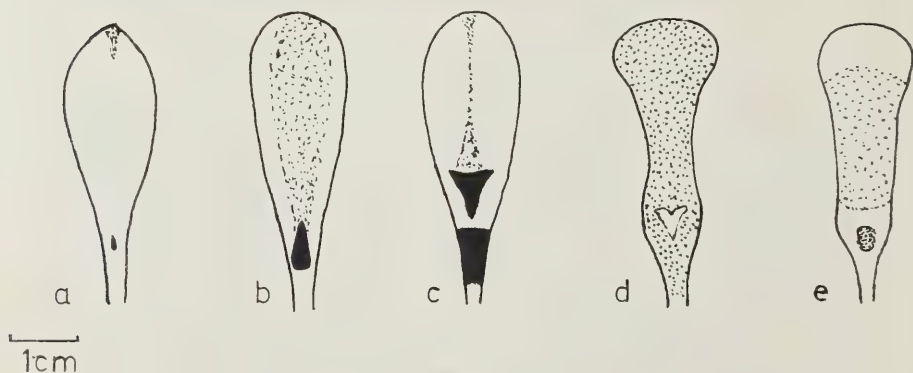


FIG. 3.

Perianth segments of a, *S. grandiflora* subspecies *acutiloba*; b, and c, of subsp. *fimbriata*; d, of subsp. *grandiflora*; e, of subsp. *violacea*.



*S. grandiflora* and its subspecies occur on damp flats or hilly slopes, from the Caledon area to the Olifants river valley.

Flowering time: August—September.

This species is complex and consists of four distinct subspecies, all of which differ from one another in one or more characters. In addition, each of the sub-species is confined to a particular geographical area, separated by mountain barriers. Intermediates are not known in nature but all the subspecies are interfertile.

#### KEY TO THE SUB-SPECIES

- |  |                       |
|--|-----------------------|
| 1. Perianth segments spatulate   |                       |
| 2. Leaves lanceolate, sometimes curved, acuminate and lightly ribbed; flowers frequently red-purple, sometimes white; occurring in the Tulbagh valley..... | a. <i>grandiflora</i> |
| 2'. Leaves broadly falcate, obtuse-acuminate and strongly ribbed; flowers light purple or white; occurring in the Caledon area.....                        | c. <i>violacea</i>    |
| 1'. Perianth segments lanceolate to ovate  |                       |
| 3. Segments broadly lanceolate and acute; flowers yellow or purple....   | d. <i>acutiloba</i>   |
| 3'. Perianth segments ovate and obtuse; flowers cream coloured, marked with purple .....   | b. <i>fimbriata</i>   |

#### 6a. Subsp. *grandiflora*

*Plants* less robust than in the other subspecies. *Leaves* 6—20 cm long, 1 cm broad, lanceolate and acuminate or acute, lower leaves somewhat falcate. *Flowers* usually deep red-purple, white and sometimes marked with light purple; *perianth tube* yellow, red purple outside; *perianth segments* 2·5—3·0 cm long 0·8—1·4 cm broad, spatulate and obtuse.

Damp, clay flats and slopes in Tulbagh valley between Tulbagh and Artois.

Flowering time: September.

*Icones*: Ker., in Bot. Mag.: t. 541 (1804) as *Ixia grandiflora*; Ker., in And. Bot. Rep. 2: t. 87 (1797) as *I. aristata* var *atropurpurea*; Jacq., Hort. Schoen.: t. 17 (1797) as *I. holosericea*; Marloth. Fl. S. Africa 4: pl. 43 E.

CAPE—3319 (Worcester): Artois (Tulbagh) (—AD), *Compton* 11677 (NBG); Tulbagh, *Ecklon & Zeyher* 111 (SAM); Artois, *Esterhuysen* 6080 (BOL); near Tulbagh Road Station, *Goldblatt* 303 (BOL); Tulbagh, *Grant* 2470 (PRE); 2 miles south Tulbagh, *Lewis* 5741 (NBG); Steendaal, Tulbagh, *MacOwan* 583 (BOL, SAM), *Pappe s.n.* (SAM 48516); Tulbagh Kloof, *Stokoe and Davis s.n.* (SAM 63511).

This subspecies is distinguished by its distinctly spatulate petals. The majority of plants are a deep red-purple colour but pure white and intermediate

individuals are not rare. It is extremely localised, being known only from the Tulbagh valley.

*S. grandiflora* was described by de La Roche in his doctoral thesis published in 1766. The type is, however, unknown. La Roche mentioned that he obtained specimens of many species from several people including Linnaeus, but he did not indicate any more than this. It does seem that his description was based on a pressed specimen(s) as the corm is not discussed. N. E. Brown (1929) has suggested that the type of *Ixia monathos*, another species described by La Roche in the same work, is in the Burmann Herbarium, Geneva. This specimen does match La Roche's description closely, and the handwriting on this sheet is thought to be his, but there does not seem to be an inscription in a similar hand on specimens of *S. grandiflora*. Thus there does not seem to be more than the flimsiest circumstantial evidence that the type of *S. grandiflora* is in Burmann's collection.

In the absence of further evidence a neotype is proposed. There is little doubt that La Roche's description applies to the Tulbagh form as he describes the flowers as large and deep violet and the perianth segments as dilated at the tip (i.e. spatulate). It is these very features which serve to distinguish this sub-species. *S. grandiflora* was long considered to include both the purple and white flowered forms, one or another of which was often listed as a variety.

6b. Subsp. **fimbriata** (Lam.) Goldblatt comb. nov. et stat. nov.

*Ixia fimbriata* Lam., Encyc. 3: 339 (1789). *Sparaxis fimbriata* (Lam.) Ker. in Kon. & Sims, Ann. Bot.: 225 (1805) Basionym.—Iconotype: Mill. Dict. Fig. Pl. 237, f. 1, 2. *Ixia liliago* D.C. in Red. Lil.: t. 109 (1804). *Sparaxis liliago* (D.C.) Sweet, Hort. Brit. ed. 2.: 501 (1830); Klatt, Ergänz.: 56 (1882). *S. grandiflora* var *liliago* (D.C.) Ker. in Bot. Reg.: t. 258 (1817); Baker in Journ. Lin. Soc. Bot. 16: 99 (1878).—Iconotype. Red. Lil. t. 109. "*S. grandiflora*" sensu Bak., Handbk. Irid.: 197 (1892) pro parte excl. plantae florum purpurearum; Bak., Fl. Cap. 6: 116 (1896) pro parte excl. plantae florum purpureorum; Lewis in Adamson & Salter Fl. Cap. Pen.: 245 (1950) pro parte excl. plantae florum sine maculata. *S. grandiflora* var *striata* Sweet, Hort. Brit. ed ii: 501 (1830).—Iconotype: Ker., in Bot. Mag.: t. 779. "*S. anemonaeflora*" sensu Ecklon. Top. Verz.: 27 (1827).—Lectotype. Ecklon 763 (PRE).

*Plants* usually very robust. *Leaves* seldom up to 20 cm long, usually less than 10 cm, the flowers borne well beyond the leaves, the leaves ensiform or falcate, acuminate or obtuse acuminate when falcate. *Flowers* zygomorphic, distinctly marked; *perianth tube* bright yellow, purple outside; *perianth segments* cream to pale yellow with fairly large black blotches at the base and streaked externally

with broad purple marks so that unopened flowers are purple or lightly marked at the base and not purple streaked externally, narrowly ovate, obtuse 2·8—4·0 cm long, 1·4—1·6 cm broad.

Fairly damp clay flats and hills round Cape Town, and northwards as far as Darling, Piketberg and Porterville areas.

Flowering time: August—September.

*Icons*: Miller. Ic. Pl. t. 237 fig. 2. (1760) as *Ixia* sp.; Redoute, Lil. t. 109 (1805) as *I. liliago*; Ker., in Bot. Mag. t. 779 (1804) as *S. grandiflora* var.

CAPE—3218 (Clanwilliam): near Piketberg (—CD), *H. Bolus* s.n. (BOL 29582); Piketberg, *Compton* 15007 (NBG)

—3318 (Cape Town): Hopefield (—AB), *Marloth* 10598 (PRE); Darling (—AC), *Engelbrecht* s.n. (BOL 29584); Modder River turnoff, Darling Road, *Goldblatt* 300 (BOL); near Porterville (—BB), *Barker* 5846 (NBG); north of Wellington (—CB), *Goldblatt* 302 (BOL); Paarl, *Hutchinson* 466 (NBG); Elsenberg (—CC), *Grant* 2514 (PRE); Bottelary Road, Bellville, *Lewis* 2240 (SAM); Stellenbosch flats, *Mauve* 4575 (PRE); southern outskirts of Paarl, *Story* s.n. (PRE 30485); Stellenbosch, *Strey* 495 (PRE); Welgemoed, Bellville (—CD), *Loubser* 2110 (BOL); Mamre Hills (—DB) *Barker* 1344 (NBG); Groenekloof, *H. Bolus* 4344 (BOL); *Zeyher* 779 (SAM); Signal Hill (—DC), *Barker* 453 (NBG), *Wilms* 3755 (Z), *Wolley-Dod* 579 (BOL); Lions Head, *Ecklon* 763 (PRE, Z), *MacOwan* s.n. (BOL 29583, SAM, 21311), *Thode* 9173, 2212, 12873 (H.U.S.); Blinkwater, *Rehmann* 1300 (Z),

—3319 (Worcester): Dal Josaphat (—DA), *Grant* 2346 (PRE),

—3418 (Simonstown): Faure (—BB); *Barker* 2986 (BOL); Hottentots Holland, *Ecklon* 113 (SAM); Faure flats *Hutchinson* 497 (PRE, BOL).

#### DOUBTFUL LOCALITIES

—3219 (Wupperthal): Olifants River Valley, *Leipoldt* s.n. (BOL 29583); Wupperthal (—AD), *MacOwan* s.n. (SAM 21312).

—3319 (Worcester): Tulbagh, *Ecklon & Zeyher* s.n. (PRE 22348).

This subspecies is distinguished from subsp. *grandiflora* and the other subspecies by the shape of the perianth segments which are narrowly ovate and obtuse. The colour and markings of the flower are also distinctive, being cream to pale yellow with small or large black blotches at the base of the segments, having narrow or broad external purple streaks down the centre of the lobe in most populations and a yellow perianth tube. Populations from the Mamre-Darling area have the narrowest purple streaks and smallest internal blotches.

This is most frequently confused with *S. bulbifera* as the flowers of both

species are whitish to pale yellow. The markings and shape of the perianth segments are distinct even if the peculiar features of *S. bulbifera*, namely the branching and the cormlets, are not apparent. It is probably due to this confusion that subsp. *fimbriata* has a rather involved taxonomy.

It may be discovered later that *Ixia sparsa* Miller is the earliest name for this subspecies. Lamarck lists this as a synonym of *I. fimbriata* and also gives two of Miller's figures as types. The description of *I. sparsa* is unfortunately quite inadequate to place it even in the genus *Sparaxis*, nor is there a type in the British Museum, where Miller's types are housed. If the figures which are the type of subsp. *fimbriata* can in some way be linked to *I. sparsa* then this will be a synonym.

6c. subsp. **violacea** (Ecklon) Goldblatt stat. nov. et. comb. nov.

*Sparaxis violacea* Ecklon, Top. Verz.: 27 (1827) Basionym. Klatt Ergänz.: 55 (1882). "*S. bulbifera* var *violacea*" sensu Baker, Handbk. Irid.: 197 (1892) et Fl. Cap. 6: 116 (1896).—Lectotype. *Ecklon & Zeyher 114* (SAM).

*Plants* not robust, usually short and rarely up to 20 cm high. *Stem* unbranched. *Leaves* up to 8 cm but often less, 0·6—1·2 cm broad, closely ribbed, falcate and obtuse-acuminate, rarely acuminate. *Flowers* zygomorphic; *perianth tube* yellow or cream; *perianth segments* white with or without violet marks at the base, and sometimes streaked externally, or violet with white at the base and apex, spatulate and obtuse, 2·2—2·6 cm long, 1·2 cm broad.

Damp clay flats in the Caledon district from Botriver and Villiersdorp to Riviersonderend and Napier.

Flowering time: August—September.

CAPE—3519 (Caledon): Botriver Caledon (—AA), *Ecklon & Zeyher 114* (SAM); 16 miles north of Botriver, *Goldblatt 295* (BOL); 6 miles south Villiersdorp on Caledon Road, *Salter 4786* (BOL); lower slopes Houw Hoek, *Walgate 1081* (SAM); lower slopes Houw Hoek, *Wilman 840* (BOL); Zwartberg, Caledon (—AB), *Ecklon & Zeyher 115* (SAM, PRE); 1 mile south of Caledon, *Goldblatt 300* (BOL); Drayton siding, east of Caledon (—BA), *Goldblatt 334* (BOL); between Lindeshof and Greyton; *Lewis 5662* (NBG); Appelpkraal, Riviersonderend (—BB), *Ecklon & Zeyher s.n.* (SAM 21304); Fairfield, near Bredasdorp (—BC), *Lewis 5283* (NBG).

This subspecies may be recognised by its slightly spatulate perianth segments, short, comparatively broad, closely ribbed leaves which are almost invariably falcate and obtuse acuminate. The perianth segments are either

uniformly white or marked with violet near the base, or are violet fading to white at the base and apex.

It is spread through the Caledon area and appears to share the same ecological niche as *S. fragrans* but the two have not been observed growing together. It is clearly part of the *S. grandiflora* complex, but is geographically isolated from the other subspecies, and differs in flower colour and form.

It is perhaps rather inaptly named, as the flower colour in several populations, especially east of Caledon, is pure white.

6d. Subsp. **acutiloba** Goldblatt, subsp. nov.

"*Ixia bulbifera*" sensu Ker. in Bot. Mag.: t. 545 (1801). "*S. bulbifera*" sensu Baker in Linn. Soc. Bot. 16: 98 (1878) pro parte, sole ad plantas florum luteorum refert; Bak., Handbk. Irid.: 197 (1892) et Fl. Cap. 6: 115 (1896).? *Ixia monathos* de La Roche, Dissert. Descript. Pl. Nov.: 21. (1766);? *Sparaxis monathos* (de La Roche) N. E. Brown in Kew Bull. 4: 135 (1924).—? Type. *Burmamn s.n.* (G).? *Sparaxis lutea* Ecklon, Top. Verz.: 28 (1827) uterque pro parte sole ad plantas florum luteorum refert.

Ab aliis subspeciebus perianthii segmentis acutis et lanceolatis distinguitur.

*Plantae* saepe graciles et elatae sed interdum parvae. *Caulis* 1—3 (numero) 8—45 cm longa, gracilior, glabra. *Folia* 7—10, erecta ensiformia, 5—30 cm longa. *Flores* zygomorphae; *perianthii tubus* luteus; *segmenta* lutea, interdum nigra maculata vel striata externe, vel segmenta purpurea, lanceolata et acutae, raro subobtusae, 2·4—2·9 cm longa, 1·2 cm lata.

Distinguished from the other varieties by its smaller flowers the segments of which are lanceolate and acute, occasionally narrowly obtuse. When growing under favourable conditions this is the tallest of the subspecies.

*Plants* are fairly tall and slender reaching to 45 cm in height, but sometimes much smaller. *Stem* 8—45 cm high, comparatively slender, glabrous, 1—3 in number. *Leaves* 7—10, erect, ensiform acuminate, 5—30 cm long. *Flowers* zygomorphic, brightly coloured; *perianth tube* yellow; *perianth segments* bright yellow, sometimes spotted or striped externally with black, or flowers purple, lanceolate and acute or sub-obtuse, 2·4—2·9 cm long, 1·2 cm broad.

Damp clay banks and hills in Olifants River Valley extending from Warmbaths to Clanwilliam and as far as Vredendal, where a purple form occurs.

Flowering time: August—September.

*Icones*: Ker., in Bot. Mag.: t. 545 (1801) as *Ixia bulbifera*.



CAPE—3218 (Clanwilliam): Clanwilliam (—BB), *Guthrie* 3356 (BOL); Clanwilliam, *Loubser* 940 (NBG); 1 mile from Alpha on Algeria Road (—BC), *Gillet* 4133 (BOL); 8 miles south Clanwilliam *Goldblatt* 264 (BOL); 18 miles south Clanwilliam, *Goldblatt* 263 (BOL); Alpha, *Hugo* s.n. (BOL 29589); 10 miles north Citrusdal, *Lewis* 1344 (SAM); between Clanwilliam and Citrusdal, *Lewis* s.n. (BOL 20308); Olifants River Valley, *Schelchter* 4990 (BOL, Z), *Penther* 681, 610 (Z),

—3219 (Wupperthal): 5 miles north Citrusdal (—DA), *Barker* 3606 (NBG), *Compton* 20764 (NBG). *Leighton* 1095 (BOL); 6 miles north Citrusdal, *Barker* 7397 (NBG); Warmbaths, *Leipoldt* s.n. (BOL 29588).

#### DOUBTFUL LOCALITY

—3318 (Cape Town): Malmesbury (—BD), *Blinkiron* s.n. (NBG 63037).

Although this subspecies has been known for many years it has long been mistakenly referred to *S. bulbifera*. It may be the plant which Ecklon called *S. lutea* but this name is excluded as the description is inadequate. As yet, the type of *S. lutea* has not been located.

#### GEOGRAPHICAL DISTRIBUTION

The genus is confined to the South Western Cape. Except for *S. bulbifera*, each species or subspecies has a very local distribution. The least specialised species, namely *S. tricolor*, *S. pillansii* and *S. elegans*, have the most limited range, occurring in a small area on the Nieuwoudtville plateau. These three species of *Sparaxis* can perhaps be regarded as relicts, having evolved in this small area from once far more widespread ancestors. The remaining actinomorphic species, *S. fragrans*, is also localised and occurs over a portion of the Caledon area.

Both the zygomorphic species have a wide range. The *S. grandiflora* complex is widespread although some of the sub-species have a limited distribution. Subsp. *violacea* is found in the northern part of the Caledon area, subsp. *acutiloba* in the Olifants River Valley, subsp. *grandiflora* in the Tulbagh valley and subsp. *fimbriata*, by far the most widespread, along the coastal belt from Piketberg to Cape Town. These areas are all separated from one another by mountain barriers rising about 500 feet above the valleys or plains on which the plants grow. It is not only altitude which serves as a barrier for these lowland forms, but the soil, for the mountains consist, in part at least, of sandstone and sandy soil, in contrast to the heavy clay on which all but one species of *Sparaxis* grow. It is possibly a combination of unsuitable soil and rapid drainage which limits the growth of *S. grandiflora* on these mountain regions, for as mentioned previously, all the species grow in places which are damp or water-logged during the winter growing season. It seems that *S. grandiflora* is a species evolving into

several new forms, a process promoted by isolation and consequent limitation of gene exchange, and by somewhat different climatic conditions in each area.

*S. bulbifera*, the most widespread species, occurs from the Piketberg to the Bredasdorp areas. The distribution of this species is not limited by soil type as it will grow on clay or sandy soil. The mountain ranges seem to present little barrier to its distribution. The species is found from near sea level to just above 1,000 ft in the Elgin area and around Caledon.

#### HYBRIDISATION

Very little critical work has been done on the breeding of *Sparaxis* or the related genus *Synnotia*. Interspecific *Sparaxis* hybrids have, however, been recorded on several occasions and all of the species seem to be interfertile. A few intergeneric crosses have been successfully made. The author has crossed *Sparaxis tricolor* and *Synnotia variegata* with no noticeable reduction in seed production or viability. Loubser (personal communication) has also crossed the two genera and has raised a sturdy hybrid generation.

Many of the garden forms of *Sparaxis* are interspecific hybrids, and these are almost all fertile and are usually more vigorous than the parental forms. From the few reports available it seems that hybrids of *S. tricolor* and *S. elegans* have been raised (L. Bolus 1932b) and *S. pillansii* is a suspected parent of several hybrid forms. The author has crossed *S. tricolor* with *S. elegans*, and reciprocally crossed *S. elegans* and *S. grandiflora* subspecies *acutuloba*. Fertility was not noticeably reduced, and the offspring of the latter cross are vigorous though they have not yet flowered.

Breeding work has been carried out at the Bienne Donne Experimental Farm at Groot Drakenstein by Horn (1962) and is still being maintained. There is a very large number of forms at Bienne Donne, some of which are triploid and higher polyploids. Several of these hybrids closely resemble species which were described early in the nineteenth century and confirm the suspicion that these were in fact hybrids. Among those which were previously recognised as distinct species or synonyms of other species are:—

<i>S. blanda</i>	Sweet	Hort. Brit. ed. ii: 501 (1830)
<i>S. griffini</i>	Sweet	Hort. Brit. ed. ii: 501 (1830)
<i>S. lineata</i>	Sweet	Br. Fl. Gard. ser. ii: t. 131 (1832)
<i>S. stellata</i>	Roem. & Schult	Syst. Veg. ed. i. 1: 400 (1817) as <i>Ixia stellata</i>
<i>S. versicolor</i>	Sweet	Br. Fl. Gard. ser. i: t. 160 (1826).

The first four are clearly related to *S. tricolor* and the last seems to be a hybrid of *S. tricolor* and *S. grandiflora* subsp. *grandiflora*.

The breeding experiments of Horn indicate that *Sparaxis* is usually cross

fertilised, as naturally or artificially selfed flowers showed much reduced fertility. Whether the crosses were performed between the same or other species made no difference to the fertility.

#### DISCUSSION

##### *Cytology*

It must be pointed out that the literature on the cytology of the South African Iridaceae is rather scanty. The author is, however, engaged on research in this field and although nothing has as yet been published, some comments can be made with authority.

The chromosome number of 20 (diploid) is found in at least eight genera including the group of genera under discussion. This number is also found in some species of *Moraea* and *Dietes* (Sakai 1952; Fernandez and Neves 1961; Sharma and Sharma 1961), in *Chasmanthe aethiopica* and in the genus *Micranthus*. In *Moraea* and *Dietes* the chromosomes are larger than those of *Sparaxis* by a factor of about 100 and have a remarkably different appearance. *Chasmanthe* has uniformly small chromosomes, while in *Micranthus* there is a single pair of conspicuously large ones and the others are small.

From the authors knowledge and from the existing papers on the subject it can be said that the diploid number of 20 is the only number occurring in species of *Dierama* and *Ixia*. (Darlington and Wylie 1950, Brittingham 1934, Fernandez and Neves 1951). This is also true of *Sparaxis* and *Synnotia* (Brittingham 1934). Together with the similarity in karyotype, this is probably indicative of the close relationship of these four genera. That *Sparaxis* and *Synnotia* both have smaller chromosomes than *Dierama* and *Ixia*, may also be significant, for Stebbins (1950) has pointed out that decreasing chromosome size can often be correlated with more advanced morphological features and the corresponding specialization.

##### *Phylogeny and Evolution*

Both cytological and morphological evidence seem to indicate that the *Dierama*, *Ixia*, *Sparaxis*, *Synnotia* complex are a natural group. As mentioned earlier *Dierama* is the most primitive of the group as it has the least specialized characteristics; evergreen habit (in most), branched inflorescence, persistent corms, a short perianth tube and regular flowers. It also has the widest geographic distribution. As Lewis (1962) pointed out, *Ixia* may have evolved from *Dierama* due to the more taxing ecological conditions prevailing in the South Western Cape. The smaller, short-living corm, deciduous habit and reduced size are probably far better adapted to the long, dry, hot summers and wet winter and short spring period occurring in this area.

*Sparaxis* and *Synnotia* may have evolved independently from *Dierama* and

although the bracts are rather less modified than *Ixia*, floral specialization has occurred. The end result of this line is the strongly zygomorphic flowers of *Synnotia*.

#### DOUBTFUL AND EXCLUDED SPECIES

A list of doubtful and excluded species has been compiled from the long list of names published under *Sparaxis*. Most belong to other genera but a few are species of doubtful affinity. A small list of hybrid species and garden forms is provided under the section dealing with hybridization.

##### *S. anemonaeflora* (Jacq.) Ker.

This species was described by Jacquin as *Ixia anemonaeflora*. It is clearly not a *Sparaxis* as it lacks the characteristic bracts. Lewis (1962) in her revision of *Ixia* stated that this plant (Jacq. Ic. Pl.: .273) is *I. campanulata* Hoult., which it resembles very closely.

The plant described by De Candolle in Red. Lil.: t. 85 as *I. anemonaeflora* is a *Sparaxis* and this has led to confusion in the application of the name. This name is however illegitimate.

##### *S. bicolor* (Thunb.) Ker.

Sweet placed this species in the genus *Synnotia* which he established in 1826. It differs from *Sparaxis* in having a longer, curved, perianth tube, arcuate unilateral stamens, and a hooded posterior perianth segment. All these characters serve to distinguish *Sparaxis* from *Synnotia*. The plant is now known as *Synnotia villosa* (Burm. f.) N. E. Brown.

##### *S. galeata* (Jacq.) Ker.

This plant, originally described as a *Gladiolus* (Jacq. Ic. Pl. t. 258) is *Synnotia galeata*. It was placed in this genus in 1826 by Sweet, for the same reasons as was the previous species.

##### *S. herbertii* Hort. nom. nud.

This manuscript name only appears on herbarium specimens and was apparently never validated. Klatt cited it in the synonymy of *Freesia xanthospila* when he described this species. The drawing in the Bolus Herbarium of this specimen in the Berlin Herbarium shows clearly that it is a *Freesia*, as it has the typical long, broad perianth tube and short lobes. This specimen was made the type of *Freesia herbertii* N. E. Brown (1930).

##### *S. joubertii* Lodd. nom. nud.

This is another species which was never described under this name. It was first listed in Delect. H. Dresden. (1813—1835) and is mentioned in Walpers Ann. Bot. 6: 49 (1861). According to N. E. Brown (1930) there is a specimen



in the Vienna Herbarium which bears the name *S. joubertii*, and the later name *Freesia xanthospila* Klatt. It is now recognised as *F. xanthospila* (D.C. in Red.) Klatt.

The name *S. jaubertii* which appeared in a seed catalogue of the Vienna Botanic gardens (Del. Sem. Hort. Vindob. 1885) is a misspelling of *S. joubertii*.

*S. lacera* Ker., nom. nud.

Specimens bearing the name *Ixia lacera* are in the Linnaean Herbarium (58/18 and 58/19). The name is, however, not valid as the specimens were never described under this epithet, but Ker. (1805) correctly placed it in *Sparaxis*. The specimens are probably *S. grandiflora* subsp. *fimbriata*.

*S. lineata* (Salisb.) Pax in Engl. & Prantl. Pflanzenf. ii. 5: 155 (1899) non Sweet (1832).

This plant, originally described as *Gladiolus lineatus* by Salisbury (1796) was *Ixia squalida* var. B of Aiton, Hort. Kew ed. i. 1: 61. This species was later placed in *Tritonia* by Ker. (1805), and it is *Tritonia lineata* (Salisb.) Ker. It has flattened corms with brown tunics and characteristic firm leaves of *Tritonia*.

*S. luteoviolacea* Ecklon, Top Verz. 27 (1827) nom. nud.

This species was not described but merely listed in Ecklon's chapter on *Sparaxis*. There are, however, specimens of this species and Lewis (1956) recognised it as *Synnotia variegata* Sweet var. *metelerkampiae*. (L. Bol.) Lewis.

*S. miniata* Klatt, Erganz. 55 (1882).

This species is something of a mystery. From Klatt's description the salient points of the plant are: lower leaves, one, ribbed, grass-like and linear; flowers two, these vermilion with yellow base, spaced far apart; bracts white, membranaceous with brown, deeply lacerate cusps; exerted perianth tube and ovate segments. The description was based on a specimen of Drège (5968), without locality, which was in Klatt's Herbarium. This collection was housed in Berlin, and is believed to have been destroyed. Unless another specimen can be located it is doubtful whether the identity of the species can be determined.

From colour alone it may be *S. tricolor*, a species already recognised by Klatt, or it may be *S. pillansii* perhaps a species of *Tritonia* e.g. *T. hyalina*.

*S. monanthos* (de La Roche) N. E. Brown in Kew Bull. 4: 135 (1924).

This was described by de La Roche (1766) as *Ixia monanthos*. From the description it is clearly allied to *S. grandiflora* but it is equally clear that it is not quite like any of the subspecies described in this paper. As it is yellow (*luteus*) it seems allied to the subspecies *acutiloba*, but no specimen of this is known with the fairly large black mark in the middle of the segments that de La Roche mentions.



A specimen with this name is in the Herb. Delessert Geneva, in Burmann's collection. According to N. E. Brown (1929) the inscription is in de La Roche's handwriting and is in fact the type. Whether this is so or not, the specimen matches the description very closely. There is however, no indication in de La Roche's thesis as to where his types are, if indeed there was one of this species.

The present author's opinion is that this species is allied to *S. grandiflora* subsp. *acutiloba*, though it may be a garden hybrid or an unusual form of the subspecies.

*S. orchidiflora* Lodd. Bot. Cab. 7: t. 1099 (1825). nom. subnud.

The plant concerned is *Synnotia variegata* Sweet var. *metelerkampiae* (L. Bol.) Lewis. It has the typical features of *Synnotia* mentioned under *S. bicolor*.

*S. pendula* (L.f.) Ker.

The genus *Dierama* was based on this species and the plant is now *D. pendulum* (L.f.) Baker. This genus is related to *Sparaxis* but differs in having a slender pendulous stem, much branched inflorescence and evergreen leaves.

*S. pulcherrima* (Hook. f.) in Bot. Mag.: t. 5555 (1866).

This is another species now referred to *Dierama*, for the same reasons as the previous species. It is now *Dierama pulcherrimum* (Hook. f.) Bak.

*S. reflexa* nom. nud.

This is another undescribed species, and it has not been illustrated. It was listed by Voigt in a catalogue of the Calcutta Bot. Gardens in 1845. The name was obtained from an M. S. of Villet and it is not possible to identify the plant upon which the name was based.

*S. thoubertii* nom. nud.

This name was used in horticultural circles during the mid 19th century, but never validated. Eventually the plant was described by Klatt in 1874, and published as *Freesia leichtlini* in Gartenflora p. 289: this is now known as *F. xanthospila* (D.C.) Klatt var. *leichtlini* (Klatt) N. E. Brown.

*S. wattii* Harvey in Gen. S.A. Pl. 330 (1838).

The type is in Trinity College Herbarium, Dublin and is unmistakably *Synnotia variegata* Sweet, though the description given by Harvey is inadequate.

#### ACKNOWLEDGEMENTS

I wish to extend my thanks to Professor E. Schelpe of the Bolus Herbarium for his help, encouragement and guidance, Miss W. F. Barker of the Compton Herbarium, Mr. H. Tölken of the Botany Dept., U.C.T. and Mrs. A. A. Mauve

of the National Herbarium, Pretoria, for their helpful comments, Professor T. T. Barnard for his advice and help, the McGregor family of Nieuwoudtville for their help with species located in that area, Mr. J. W. Loubser and Mrs. M. Thomas for the specimens they provided, Mr. T. J. Roos of Bienne Donné Experimental Farm at Groot Drakenstein, the curators of the various herbaria who lent their specimens and Mr. A. Fricke of the Botany Dept. U.C.T. for his help with the photography.

I must also thank Mr. R. Wilsenach, Mrs. L. E. Davidson and Mrs. W. Macnae for their initial help and encouragement when this study was undertaken.

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## HISTOCHEMICAL LOCALISATION BY ELECTRON MICROSCOPY OF PECTIC SUBSTANCES IN ABCISING TISSUE

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### ABSTRACT

Pectic substances may be localised in abscising plant tissue at the electron microscope level using postfixation and postsectioning rather than prefixation staining techniques. The results, though not always consistent, have considerable value in interpreting changes which occur in the pectic substances of cell walls prior to and during abscission. The non-specificity of the heavy metal dye, ruthenium red, an often used stain for pectic materials in light microscopy, appears to be borne out by electron microscopy. Alkaline hydroxylamine-ferric chloride not only is specific for pectic substances but also forms a stable, electron dense complex with the latter. The observation that auxin delays abscission by some functional regulatory relationship with the pectic substances is supported by the localisation of these substances in auxin-treated tissue of an advanced age.

### INTRODUCTION

Abscission is a process in which, ultimately, breakdown of cells leads to the disjunction of plant parts. The architecture and composition of the cell wall is such that separation must involve profound chemical as well as anatomical changes, especially in the pectic components of the middle lamella. The histochemical localisation of pectic substances (Gee et al., 1959; Albersheim et al., 1960, 1963) suggested that an electron microscopic study of their distribution in the cell walls of abscising tissue might be instructive, particularly in relation to the abscission-accelerating and abscission-retarding effects of certain plant growth substances.

This paper reports on attempts to localise pectic substances with the electron microscope using a postsection rather than Albersheim's and Killias' (1963) prefixation staining technique. The obvious advantages of staining after sectioning include more uniform staining as a result of better control and a comparison of serial sections of the same tissue following different staining treatments.

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Accepted for publication 12th December, 1968.

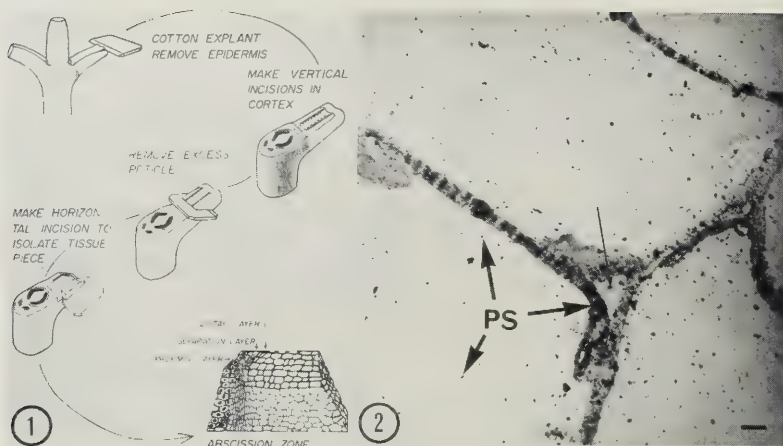


FIG. 1.  
Isolation of abscission zone for electron microscopy.

FIG. 2.  
Broad localisation of pectic substances (PS) in freshly excised tissue from the abscission zone of *Gossypium*.

#### MATERIALS AND METHODS

**Tissue preparation.** Tissue pieces, ca. 2 mm<sup>3</sup>, dissected from the abscission zones of variously treated *Coleus* and *Gossypium* explants (Fig. 1), were fixed for 2 hours in 3 or 6% phosphate-buffered glutaraldehyde, pH 6.8. The material was then divided into two lots, half of which was postfixed in 1 or 2% osmium tetroxide in veronal-acetate buffer, pH 6.5, for 2 hours, and half in 2% potassium permanganate for 2 hours. The osmium-fixed tissue was washed for 2 hours with veronal-acetate buffer and the permanganate-fixed material with water until the colour disappeared.

Following dehydration the tissue was infiltrated with and embedded in epoxy resin, one lot of tissue in a Maraglas preparation by a method modified from Freeman and Spurlock (1962), and the remaining lot in an Epon resin mixture (Bornman, 1967). Sections were satisfactorily cut with a diamond knife, ca. 600-800 Å thick.

**Histochemical localisation of pectic substances.** The localisation of pectic substances before fixation has been elegantly demonstrated at the electron microscope level by Albersheim and Killias (1963). Bornman (1967) briefly reported on the application of this technique after thin-sectioning. Upon treatment with basic hydroxylamine pectic substances form the derivative pectic

hydroxamic acids which exhibit nonselective density to electrons. However, following a reaction with a ferric salt the resulting insoluble complexes become electron dense. It appears that the amount of ferric ion is proportional to the concentration of pectic methyl ester groups rather than to total pectic substances.

Sections collected on copper and titanium grids were either floated on the staining solution, section side down, or submerged in the staining solution, section side up. The staining solution and the sequence of treatments were as follows:

Solution A: 60% solution of alkaline hydroxylamine (equal volumes of 14g NaOH per 100 ml and 14g  $\text{NH}_2\text{OH}\cdot\text{HCl}$  per 100 ml) in ethanol, 2—15 minutes.

Solution B: 95% ethanol: conc. hydrochloric acid (2 : 1), gentle washing for 1—5 minutes.

Solution C: 10% ferric chloride solution in 60% ethanol containing 0.05N HCl, gentle flooding for 1—5 minutes.

Plant tissue not pretreated with basic hydroxylamine but stained directly with ferric chloride served as control.

In addition, some sections were stained by floating on or submerging in a freshly made, aqueous ruthenium red solution (1 : 10,000) for 5 hours. Ruthenium red is a dye commonly used in light microscopy to indicate the presence of pectic substances.

## RESULTS AND DISCUSSION

It must be pointed out that cells in abscission zones and particularly in abscising tissue generally are highly vacuolated and frequently in an advanced state of deterioration. Good fixation and infiltration is therefore extremely difficult to achieve.

Kertesz (1951) pointed out that ruthenium red is not a stain specific for pectic substances. Furthermore, although this stain does seem to have particular affinity for highly polymerized acidic carbohydrates (Siegel, 1962) such as pectic substances, it is not known which component of the latter has an affinity for this dye.

Figure 2 depicts the walls of five adjoining cells in the distal portion of an abscission zone isolated from a freshly excised cotton seedling. A broad, non-specific pattern of localisation (PS) following staining with ruthenium red is apparent although the greater concentration of this electron dense metal is found over the cell walls. The intercellular space (unlabelled arrow) is, as may be expected, relatively free of stain and consequently of pectic substances.

Figure 3 is included to show the harsh effects on the embedment medium



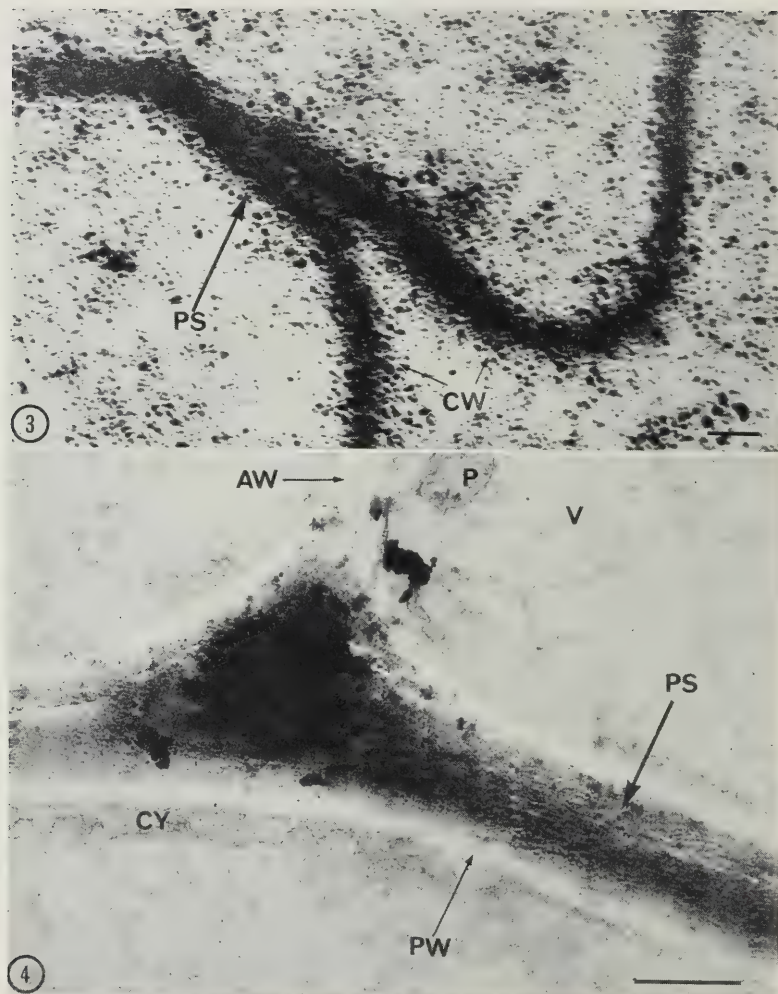
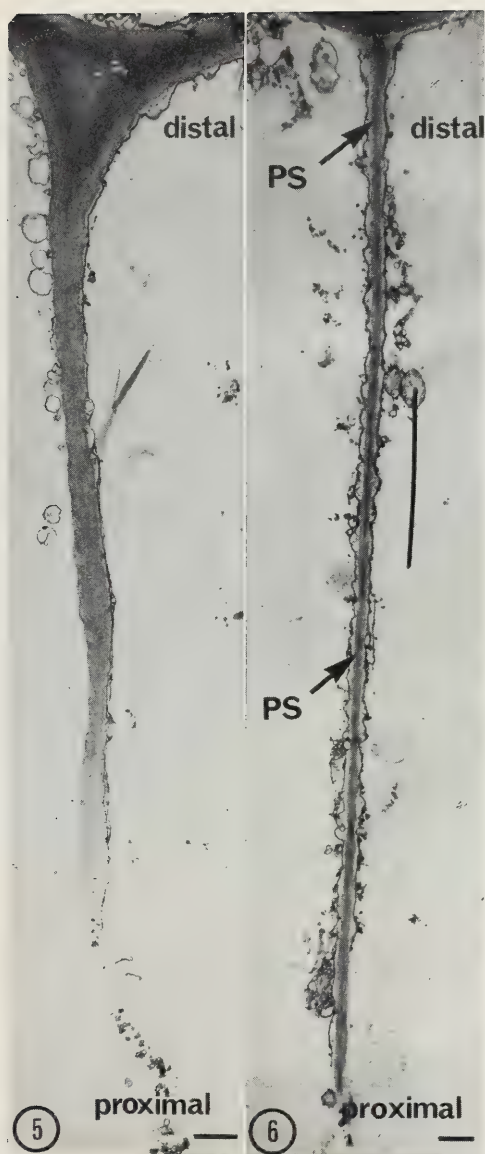


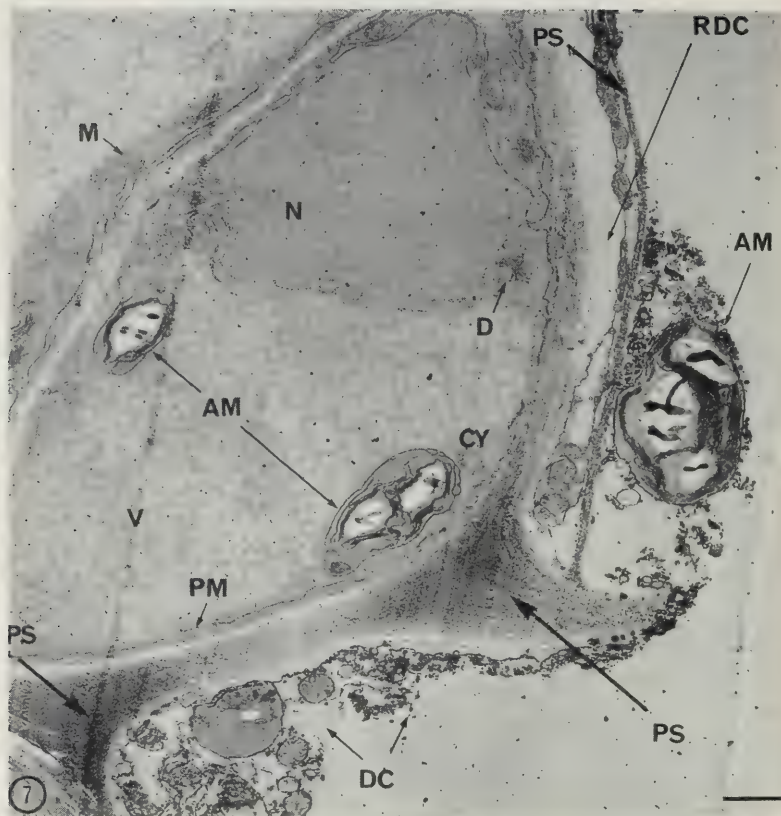
FIG. 3.  
Pectic localisation (PS) in cell walls (CW) in an overstained section of freshly excised tissue from the abscission zone of *Gossypium*.

FIG. 4.  
Uniform localisation of pectic substances (PS) in the middle lamella of a cell wall in a section of freshly excised tissue from the abscission zone of *Gossypium*. AW, axillary wall; CY, cytoplasm; P, plastid; PW, primary wall; V, vacuole.



FIGS. 5-6.

Cell wall breakdown in abscising tissue of *Coleus*, ca. 60-70 hours after deblading. FIG. 5: No pretreatment with alkaline hydroxylamine results in non-localisation of pectic substances. FIG. 6: Treatment with alkaline hydroxylamine followed by ferric chloride results in localisation of the remaining non-mobilised pectic substances (PS) of the middle lamella.

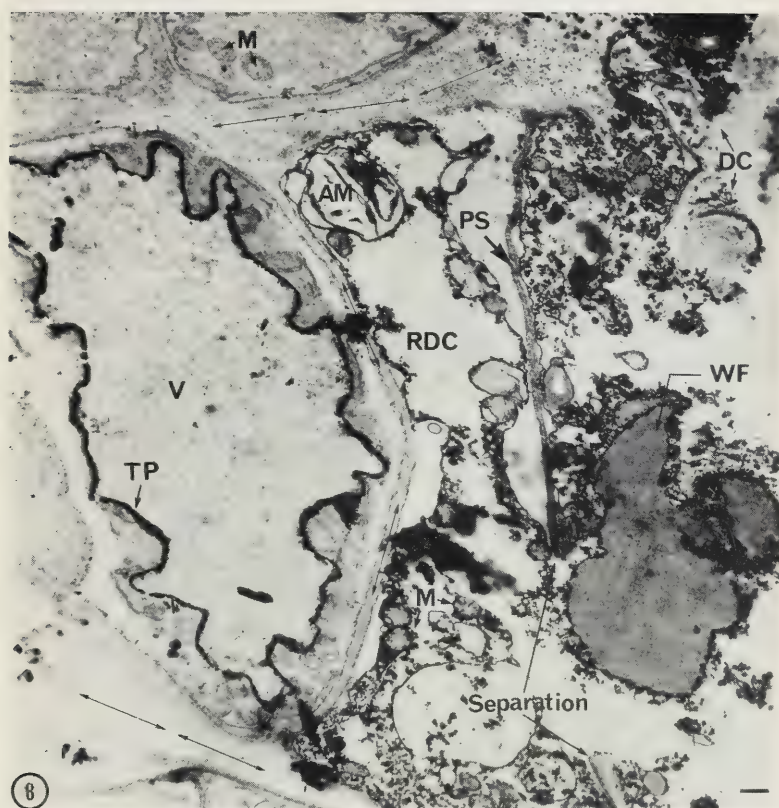


FIGS. 7-8.

Pectic substances (PS) in abscising tissue of *Gossypium* ca. 120-130 hours after treatment with indoleacetic acid at an abscission-retarding concentration. Cells are from the proximal layer. AM, amyloplast; CY, cytoplasm; D, dictyosome; DC, disintegrating cell; M, mitochondrion; N, nucleus; PM, plasma membrane; RDC, recently divided cell; WF, wall fragment.

and tissue of overstaining with ferric chloride (5 minutes). The section is from material similar to that used above (Fig. 2) but the cell contents have been destroyed by the treatment. Pectic localisation, however, is remarkably intense in a rather diffuse wall and shows at least the promise of this method.

Copper grids tended to disintegrate following treatment with  $\text{FeCl}_3$  and proved inadequate whereas titanium grids withstood the effects of the staining chemicals.



Staining of tissue similar to that represented in Figs. 2 and 3 in Solution A for ca. 5 minutes and in Solution C for ca. 2 minutes resulted in a rather more uniform localisation of pectic substances (Fig. 4, PS), mainly in the middle lamella. The primary walls (PW), and axillary wall (AW) of a young cell, indicate a low pectic content; in the latter case probably because the plane of sectioning passed mainly through primary wall. Still, the cytoplasm (CY) and a plastid (P) appear to have been damaged during staining.

Cell walls of tissue not treated with basic hydroxylamine before staining with ferric chloride did not react positively.

Abscising tissue of *Coleus*, ca. 60—70 hours after deblading and in the cell



walls of which at this stage a considerable proportion of the pectic materials is assumed to have been mobilised, shows no staining if pretreatment with hydroxylamine is foregone (Fig. 5). However, complete alkaline hydroxylamine-ferric chloride stain localises a thin band of pectic material (PS) in the wall of an abscising cell (Fig. 6).

In both *Gossypium* and *Coleus* abscission may be retarded by application of auxin; or enhanced by conditions which lower the internal level of auxin. A functional regulatory relationship may therefore exist between auxin and the pectic substances in the abscission zone. Figure 7 shows cells in the proximal

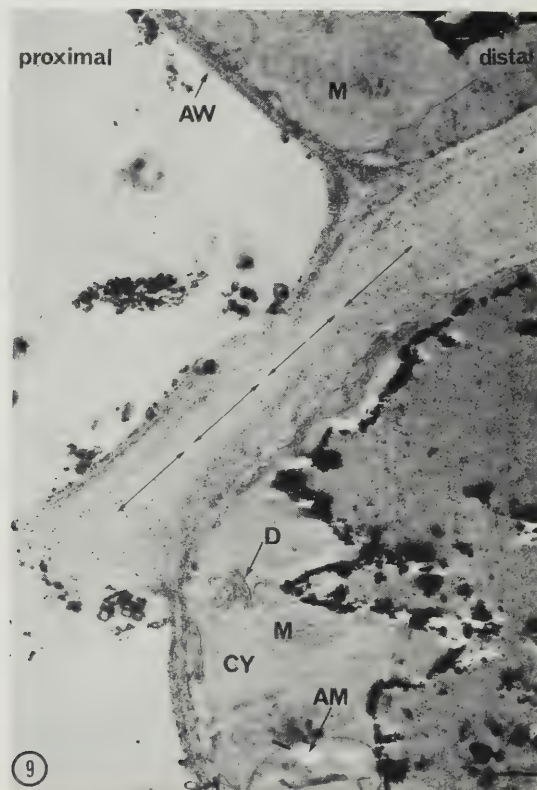
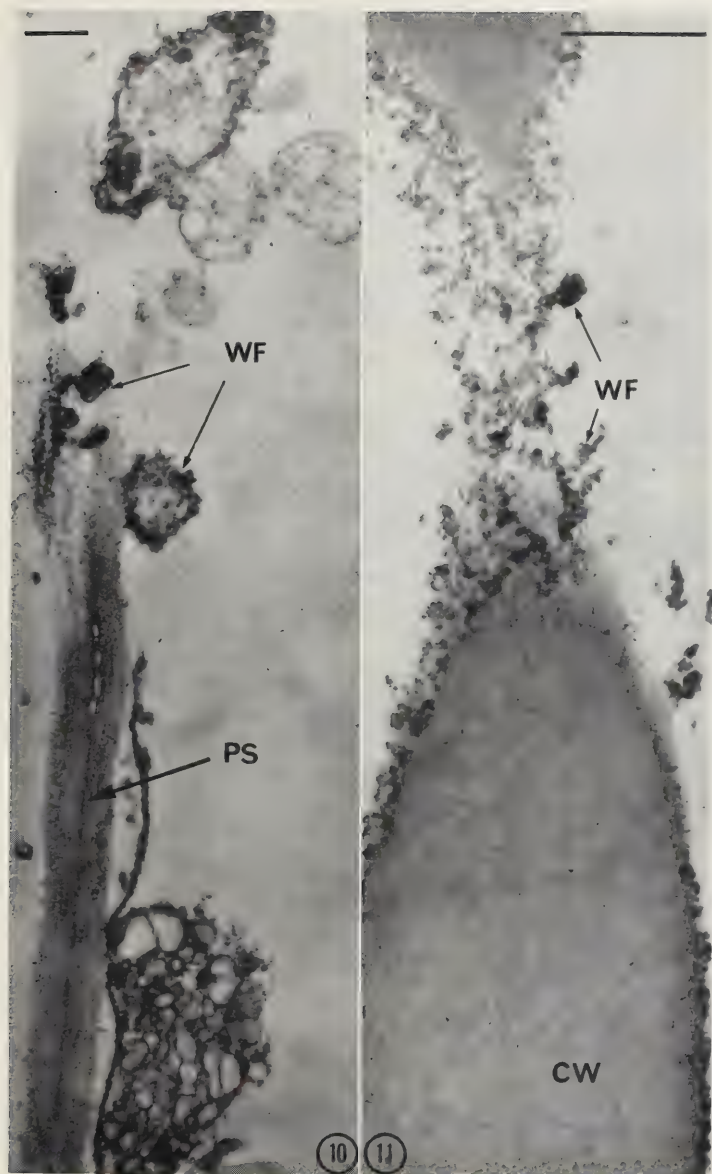


FIG. 9.

Loss of pectic substances (arrows) in abscising tissue of *Gossypium* from the distal layer ca. 120-130 hours following treatment with indoleacetic acid. AM, amyloplast; AW axillary wall; CY, cytoplasm; D, dictyosome; M, mitochondrion.





FIGS. 10-11.  
 Abscising tissue of *Coleus* following treatment with gibberellic acid at an abscission-accelerating concentration. Some pectic substances (PS) still present in the proximal part of the cell wall but have become mobilised in distal part. CW cell wall WF, wall fragment.

part of an abscission zone of a cotton explant, 120–130 hours after application of 0.25  $\mu\text{g}$  indoleacetic acid to the debladed petiole. Despite the flaccid state of plastids and mitochondria pectic substances are heavily localised in the wall of a recently divided cell (auxin stimulates cell division in abscission zones; Bornman et al., 1966) as well as in the wall junctions of adult cells. Although these cells are in an advanced state of deterioration, the presence of pectic material supports the concept of auxin's functional role in this regard. The cells in the separation layer in Fig. 8 are perhaps in an even more advanced stage of desiccation than those in Fig. 7. Pectic material has diminished in the adult cells. However, although the wall of the recently divided cell has been ruptured, probably as a result of mechanical stress, the contrast in intensity of pectic substances is marked especially where this wall abuts on to that of the mother cell.

On the other hand, cells on the distal side of the separation layer in the abscission zone, even in tissue treated with auxin as shown in Fig. 9, contain very little pectic material in mature cell walls (arrows); younger, transverse walls, contain somewhat more (AW). It is as a result of the partial or complete dissolution of the intercellular cementing (pectic) substance (Fig. 9) that walls of cells in the separation layer fall apart and lead to flower, fruit and leaf drop.

Figures 10 and 11 show parts of abscising cells in *Coleus* following treatment with 0.01  $\mu\text{g}$  gibberellic acid per abscission zone. Some pectic substances are still present in the proximal part of the wall but have become mobilised in the distal part. Figure 11 represents a fully stained section but since it is a surface section no pectic localisation is evident. Cell wall fragments (WF) indicate the final destruction of the wall.

In general it appears that osmium-fixed tissue produces better results with this staining procedure than permanganate-fixed tissue. The oxidative action of permanganate probably is responsible for this and, in addition, further adds to the poor cytoplasmic preservation. Tissue embedded in Maraglas has given slightly better results than embedment in an Epon mixture although there is reason to assume that this is probably a function of the formulation rather than of the constituent chemicals.

This technique is somewhat erratic and inconsistent, and therefore calls for caution in the interpretation of results. However, it has considerable value as a histochemical tool.

#### CONCLUSIONS

The value of the histochemical approach in localising and probably quantitatively measuring substances at the subcellular level cannot be overemphasised. However, certain criteria must be imposed: the reaction should be localised as precisely as possible in relation to the structural elements of the cell and the

final product should be an insoluble chemical complex of good quality and stability which, naturally, should be capable also of scattering or deflecting electrons.

The method of staining for pectic substances following fixation and sectioning is one that appears to have merit although the technique awaits considerable refinement. Since most investigators of abscission agree that changes occur in the pectic substances preceding and during abscission, it should be possible to examine more critically the action of hormones such as abscisic acid, gibberellin and auxin on the process of abscission by investigating their effects on the pectic components of the cell wall.

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## BOOK REVIEW

GRASSES. A GUIDE TO THEIR STRUCTURE, IDENTIFICATIONS, USES, AND DISTRIBUTION IN THE BRITISH ISLES by C. E. HUBBARD (revised edition). Harmondsworth, Middlesex: Penguin Books, 1968. 463 pp. 156 plates of line drawings. Price R1.33.

This is a revised second edition of "Grasses" by the doyen of present day Agrostologists, Charles Edward Hubbard, formerly of the Royal Botanic Gardens, Kew, now retired but still active in his chosen field. In the Preface to the second edition the additions and changes to this useful volume are summed up: four new species and several new plates are added, the notes on distribution are amended and extended following the publication of the "Atlas of the British Flora", the nomenclature is brought up to date and wherever possible additional information is incorporated in the text, keys, bibliography, glossary and indices.

The result is a work of the rare excellence one has come to expect from as exacting and meticulous a scientist as Dr. Hubbard. The black and white drawings accompanying the 156 species described were individually tested for recognition and if they failed this test were redone. As a result it is possible to name most grasses in the British Isles without recourse to a herbarium.

Brought out as a paperback it is fairly inexpensive (R1.33). The book is well bound, of a handy format and furnished with an attractive cover, somewhat marred by the superpositioning of the silhouette of a somewhat damaged herbarium specimen of a "non-British" species of *Setaria*. This was done by the publishers because "it catches the eye".

B. DE WINTER





## STUDIES IN THE XYLARIACEAE:

### VI. *DALDINIA*, *NUMULARIOLA* AND THEIR ALLIES

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#### INTRODUCTION

The genera of the Xylariaceae, excluding *Xylaria* and related series, which contain large stromata represent off shoots from *Hypoxylon* or possibly *Lopadostoma* in which there has been first the consistent production of several perithecia per stroma and second the development of one or more unusual features which separate them off rather sharply. Two series are recognizable: the first, comprising *Daldinia*, *Entonaema*, *Phylacia*, and *Thamnomycetes*, is characterized by pigment in the stroma, and the predominance of basal tissue beneath the perithecia or development of a stipe; the second, comprising *Numulariola*, includes erumpent non pigmented forms that are often effused to a great extent.

#### Series I.

1. *Entonaema* Möller A. Phycomyceten und Ascomyceten p.p. 246, 306.

In A. F. W. Schimper: Bot. Mitth. aus dem Tropen. IX, Gustav Fischer, Jena, (1901).

This genus, which has been reviewed by G. W. Martin (1938), comprises 4 species distinguished by large irregularly pulvinate to repand stromata in which the entostroma is gelatinous, forming a jelly which is persistent up to maturity and later dries out to leave hollow cavities. The entostroma becomes corky at the periphery and is covered by a conspicuous white or yellow ectostroma of similar texture. This would seem to relate it closest to the coloured members of *Euhypoxylon*. See Plate I: 1 and 2.

#### KEY TO THE SPECIES

1. Stromata substipitate; outer layer striate; spores  $5 \times 10-11\mu$ .  
*Entonaema mesenterica* Möller
- 1'. Stromata sessile; outer layer continuous.....2

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Accepted for publication 24th October, 1968.

2. Ectostroma reddish, partly evanescent at maturity; perithecia evident in outline; spores  $6.0 \times 12.0\mu^*$   
*Entonaema cinnabarina* (Cke. & Massee) Lloyd
- 2'. Ectostroma yellow-orange; spores  $5.5-6.5 \times 10.0-12.0\mu$   
*Entonaema liquescens* Möller
- 2". Ectostroma white to cream; spores  $5.0 \times 11.0\mu$   
*Entonaema pallida* G. W. Martin

No material has yet been found to yield cultures.

2. *Daldinia* Cesati V. and G. De Notaris Scheme classif. Sferiacei Ital I, 197, (1863).

*Daldinia* as presently understood was erected by Cesati and De Notaris who were the first to recognize that the large size of the stroma and the predominance and zonation of the entostroma were much more pronounced than in the related genus *Hypoxylon*. It is questionable whether these characters are sufficient to erect a genus, but, taken together with the constant production of a large number of perithecia, the 13 species discussed later in detail by Child (1932) do form a distinct series. Wakefield (1940) and Rogers (1949) conserved the genus against earlier taxa: *Hemisphaeria* Klotzsch, *Perisphaeria* Rouss., *Peripherostroma* Gray and *Stromatosphaeria* Greville.

The ascial plugs are thin (Plate IV: 6) and the structure of the stroma differs in no essential respect from the larger aplanopulvinate or hemispheric members of Euhypoxylon (*H. sclerophaeum*, *H. mulleri*, & *H. fragiforme*), with brittle refractive vinaceous ectostroma and corky entostroma; but the entostroma is zonate due to the alternate formation of long effuse and short closely packed hyphae (Plate IV: 11). According to Miller (1928), the darker zones are formed by disintegration of the perithecial initials followed by continued (?perennial) growth beyond them to produce successive zones, the number of zones being limited by the time of formation of the perithecia. The writer has observed abortive perithecial initials along the penultimate zone in *D. concentrica* but has found no evidence that any such are present deeper in the stroma. The peculiar zonate development remains a mystery, more so since the writer has observed it to take place within one season, and thus cannot represent successive increments of growth over a long time. Spores in *Daldinia* are characteristically inequilateral elliptic and dark brown to black, and do not vary greatly from one species to another except as regards size (Plate IV: 10).

The following key is modified from Child (1932):—

1. Entostroma persistent, dense, not gelatinous; dark zones predominant, some shade of brown.....2
- 1'. Entostroma persistent or collapsing, with persistent dark zonal lines, or else gelatinous in appearance; light zones predominant, white or some shade of grey.....6

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\* Decimal figures represent averages of at least 10 spores; integers mere range of dimension.

2. Stroma sessile or substipitate; stipe when present broad, exceeding 5 mm thick and not cylindric.
- 2'. Stroma definitely stipitate; stipe cylindrical, less than 5 mm thick, and supporting a globose to subglobose fertile head; spores  $7.0 \times 14.0\mu$ .  
*Daldinia loculate* (Lév.) Saccardo.
3. Ostioles umbilicate, not visible, or slightly raised; spores  $5.5-7.0 \times 12.0-13.5\mu$ .  
*Daldinia eschscholzii* (Ehrenb.) Rehm.
- 3'. Ostioles prominent, papillate to mammiform, stroma somewhat rough. . . . . 4
4. Stromata usually large, irregular, always sessile; perithecia mostly polystichous. Spores  $6.5-8.0 \times 14.5-16.0\mu$ .  
*Daldinia grande* Child.
- 4'. Stromata otherwise, spores smaller. . . . . 5
5. Mature stromata bronze-black, spores narrow ended,  $6.0-9.0 \times 12.5-16.5\mu$ .  
*Daldinia occidentale* Child.
- 5'. Mature stromata vinaceous black to dull black; spores broad ended,  $5.5-8.5 \times 11.00-14.5\mu$ .  
*Daldinia concentrica* (Bolt.) Ces. and DN.
6. (1) Entostroma dense, not collapsing at maturity. . . . . 7
- 6'. Entostroma loose, collapsing or becoming gelatinous with hollow locules. . . . . 9
7. Ostioles prominent; spores  $6.5 \times 14.5\mu$ .  
*Daldinia bakeri* Lloyd.
- 7'. Ostioles umbilicate or not visible. . . . . 8
8. Perithecia subspherical or short ovate; spores  $4.5 \times 8.5\mu$ .  
*Daldinia gollani* Hennings.
- 8'. Perithecia elongate ovate; spores  $6.0 \times 12.0\mu$ .  
*Daldinia caldariorum* Hennings.
9. (6) Stromata turbinate, regular or irregular. . . . . 10
- 9'. Stromata clavate. . . . . 12
10. Spores small,  $3.0 \times 8.0\mu$ .  
*Daldinia albozonata* Lloyd.
- 10'. Spores larger. . . . . 11
11. Stromata hard, rigid and coal black inside; basal tissue amber yellow or dull white, gelatinous and loculate; spores  $7.0 \times 12.0\mu$ .  
*Daldinia vernicosa* (Schw.) Ces. and DN.
- 11'. Stromata dark brown, ectostroma fibrous; spores  $6.5 \times 11.0\mu$ .  
*Daldinia simulans* Child.
12. (9) Perithecia confined to the upper part of the cylindrical stroma; ostioles conspicuous; stipe externally zonate with annulate thickening; spores  $5.0 \times 9.5\mu$ .  
*Daldinia cuprea* Starbäck.
- 12'. Perithecia dispersed over entire stroma, not confined to the upper half; ostioles umbilicate or not visible; spores  $5.0 \times 9.5\mu$ .  
*Daldinia clavata* Henn.

1. *Daldinia concentrica* (Bolton) Ces. and DN. (Plate V: 8)

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- Berkeley M. J. Ann. and Mag. Nat. Hist. **2**, 12, (1852); Jour. Linn. Soc. **10**, 383, (1869); Ibid. **13**, 177, (1873); Greville **4**, 48, (1875); Jour. Linn. Soc. **16**, 144, (1878). Berkeley M. J. and C. E. Broome Ibid **14**, 120, (1875); Trans. Linn. Soc. Lond. II **1**, 405, (1879). Cooke M. C. Handbook of British Fungi II, 794, (1871). Fries E. M. Nova acta reg. Soc. Scient. Upsala III, **1**, 114, (1851). Fuckel L. Symb. Myc. Nachtrag II, 43, (1873). Greville R. K. Scottish Crypt. Flora **6**, 324, (1828). Jaczewski A. L. Bull. Soc. Myc. de Fr. **11**, 115, (1895). Karsten P. A. Mycol. Fennica II: Pyr., **37**, (1873). Lambotte E. Flore Mycol. belge 424, (1880). Montagne J. F. C. in Sagra: Hist. Cuba, 340, (1838—1842); in Gay; Hist. Chile VII, 440, (1850). Nitschke T. Pyren. Germ. **1**, 25, (1867). Passerini G. Nuovo Giorn. Bot. Ital. **7**, 186, (1875). Quélet L. Champ. Jura and Vosges III 490, (1875). Rabenhorst L. Krypt. flor. Deutsch II, 866, (1887).
- sub *Peripherostroma concentrica* Gray
- Gray S. F. Natural arrangement of British Plants I, 513, (1821).
- sub *Sphaeria concentrica* Persoon
- Albertini J. D. and L. D. de Schweinitz Conspectus fungorum, 3, (1805). Berkeley M. J. in Smith: English Flora **5**, (2), 236, (1836). Currey F. Trans. Linn. Soc. Lond. **22**, 265, (1859). Durieu de Maisonneuve M. and J. F. C. Montagne Eplor. Alger. I, 451, (1846). Fries E. M. Syst. Mycol. **331**, (1823); Elenchus fungorum II, 62, (1828). Hooker W. J. Flora Scotica II, 4, (1821). Junghuhn F. H. Praemissa Fl. Crypt. Javae **20**, (1838). Nees von Esenbeck C. System der Pilze und Schwämme 290, (1817). Persoon C. H. Comment Fung. Clav. **150**, (1797); Syst. Meth. Fung. **8**, (1801—1808).
- sub *Sphaeria hemisphaerica* Nees.
- Nees von Esenbeck C. Syst. der Pilze und Schwämme 308, (1817).
- sub *Stromatosphaeria concentrica* Greville
- Greville R. K. Flora edinensis 355, (1824).

Stromata pulvinate to sub-globose, 8·5—36 × 9·5—53 × 6·5—23 mm, bases embedded in bark or wood. Initial layer orange-brown or pink, changing to reddish brown, vinaceous or sepia at maturity, or remaining orange brown. Surface usually dull matt as in *Hypoxylon* but sometimes sodden, continuous or worn off at random, exposing the brittle refractive ectostroma. Ectostroma deep orange or vinaceous, black at sight but disintegrating into particles of the same colour in microscopic preparation. Entostroma massive, corky or woody, dull brown to black, usually solid, with a large number of alternating light and dark zones. Perithecia arise near the periphery, adjacent or close crowded, long ovate, 300—900 × 900—1,500 $\mu$ ; ostioles indistinct umbilicate though sometimes raised above the stromal level, or occasionally papillate. Asci cylindric, 140—220 × 6—11 $\mu$ ; stipes 67—135 $\mu$ . Spores gibbous, navicular, or broad crescentic, rarely with narrow ends, brown, 5·5—9·5 × 10·0—16·5 $\mu$ , ave. 6·8 × 12·4 $\mu$ .

Material examined:—

A large quantity of material in the herbaria cited (Martin 1968, p. 156). Martin 509; Garden of Eden, Knysna, Western Cape, South Africa (1959). Martin 548, 550, 551; Hogsback nr Alice, Eastern Cape, South Africa, (1959). Martin 630 ex Chaves Batista; Belém, Brazil. Martin 1957; Stonybrook, Rockland Co., NY State, U.S.A., (1963). Martin



1634—6, Nyack, NY State, U.S.A., (1963). Martin 1721, 1724; Savoy State Forest, Mass., U.S.A., (1963). Martin 1764 ex Carroll 176; Elsehored Fyn, Denmark, (1962).

Cultural characters (Plate VI: 1, 2. See also Martin (1967) p. 222, fig. 3):—

Colonies cottony, dry, growing free with a rather coarse texture, mycelium very dispersed. Mycelial aggregates slight to extensive in quantity, comprising chiefly secondary mycelium. Margin not distinct, hyphae widely dispersed. Aerial mycelium dull white, sometimes partly ochraceous or green as well. Conidia formed by 7 days or when old. Stain amber, dull buff-brown, or red-brown. Growth rapid, 6·0—8·6 mm/day at 25°C.

Microscopic characters: (Fig. I: 1; Plate VIII: 11):—

Primary mycelium undiagnostic; maximum diameter of marginal hyphae = 2·5 $\mu$ . Secondary mycelium reticulate-tentacular, also with irregular globose swellings, 1·2—2·5 $\mu$  diameter.

Imperfect stage (Plate VIII: 8—10):—

Brooks F. T. Trans. Brit. Mycol. Soc. **4**, 245, (1913). Elliott J. S. B. Ibid **6**, 269—273, (1920) (sub *Nodulisporium tulasnei* Molliard). Jaczewski A. L. Bull. Soc. Myc. de France **11**, 115, (1895) (sub *Hypoxylon*). Miller J. H. Mycologia **20**, 328, (1928). Molliard M. Bull. Soc. Myc. de France **20**, 55—60, (1904).

Conidiophores are only distinct from the vegetative mycelium when warted; colourless, variable in length, 27—450  $\times$  1·8—3·1 $\mu$ , unbranched to branched indefinitely, dichotomously or with 3—4 branches off the same node. Fertile branches narrow or swollen clavate lying freely or in trident formation, heads unspecialized or slightly swollen, 8·5—120  $\times$  1·5—3·7 $\mu$ . Conidia acrogenous, globose, oval, or sometimes narrow clavate or botuliform, white en masse, 3·7—5·0  $\times$  4·3—8·7 $\mu$ , ave. 4·1  $\times$  6·3 $\mu$ .

The descriptions in the literature approximate closer to the *Acrostaphylus* type of conidiophore observed by the writer for *D. eschscholzii* than to *D. concentrica* as cultured by the writer. The form of imperfect stage of *D. concentrica* varies from *Sporothrix* to a simple type of *Acrostaphylus* only.

## 2. *Daldinia occidentale* Child

Child M. Ann. Mo. Bot. Gard. **19**, 453, 1932.

Stromata pulvinate to hemispheric, 6·0—32  $\times$  9—43  $\times$  6·0—17 $\mu$ , arising from a central point or from an ill-differentiated stipe up to 6·5 mm in diameter and 5 mm high. Surface of stromata smooth, reddish-brown; ectostroma brittle refractive, black at sight but yielding vinaceous particles in microscopic section, entostroma massive, dull brown to black, solid, with several zones of alternating light and dark colour, the latter predominant. Perithecia close crowded, evident at vertices to completely immersed, long ovate, 400—600  $\times$  900—1500 $\mu$ ;

ostioles umbilicate, not visible or minutely papillate. Asci not seen. Spores elliptic, gibbous or navicular, narrow ended, dark brown, opaque,  $5.0-10.0 \times 10.5-20.0\mu$ , ave.  $6.8 \times 13.6\mu$ .

Material examined:—

Martin 680; culture ex CBS, Baarn. Martin 873, 874; Arcata, N. California, U.S.A. (1961). Martin 910, 936, 937, Mazatlán, Sinaloa, Mexico (1961). Martin 984, 1542; San Blas, Nayarit, Mexico, (1961, 1962). Parks 3927; on *Alnus rubra*, Humboldt Co., Trinidad, California, U.S.A., (1931), (NYBG). Zeller; on *Alnus*, Waldport, Ore., U.S.A., (1929), (NYBG).

Cultural characters:—

Colonies cottony, dry, dull white, growing freely with coarse texture; mycelial aggregates extensive. Margin not distinct, entire, hyphae compact, conidia developing by 7 days but not conspicuous. Stain red brown, amber or bottle green. Growth rapid,  $6.0-6.7$  mm/day at  $25^\circ\text{C}$ .

Microscopic characters:—

Primary mycelium undiagnostic; marginal hyphae with a maximum diameter of  $2.5\mu$ . Secondary mycelium uniform or with irregular globose swellings, loose or reticulate-tentacular,  $1.2-7.5\mu$  diam.

Conidiophores and conidia (Plate VIII: 12, 13):—

Conidiophores hardly distinct from the vegetative mycelium,  $30-360 \times 1.2-2.5\mu$ , unbranched to indefinitely branched dichotomously or ternately over the apices or upper parts of the main axes. Fertile branches narrow, lying freely or in trident formation, with unspecialized heads,  $9.6-49 \times 1.8-2.5\mu$ . Conidia acrogenous, sessile or on stout sterigmata, long clavate to botuliform, white en masse,  $1.2-3.1 \times 4.3-7.5\mu$ , ave.  $2.4 \times 5.4\mu$ .

This species may only be a variant of *D. concentrica* but is distinguished by its slightly smaller stromata, absence of purple colouration, and the narrower conidia.

### 3. *Daldinia eschscholzii* (Ehr.) Rehm.

Baker C. F. Leaf. Philipp. Bot. 7, 2485, (1914). Child M. Ann. Mo. Bot. Gard. 19, 458, (1932). Ferdinandsen C. & O. Winge Bot. Tidskrif 29, 13, (1909). Miller J. H. Bothalia IV, 252, (1942). Rehm H. Ann. Mycol. 2, 175, (1904); Ibid 5, 211, (1907); Leaf. Philipp. Bot. 6, 2206, (1914); Ibid. 6, 2273, (1914) Saccardo P. A. & A. N. Berlèse Atti R. Inst. Ven. Sci. Lett. & Art. 3, 3, (1885). Starbäck K. Arkiv. für Bot. 5, 29, (1905).

sub *Daldinia concentrica* var *eschscholzii* Bres.

Bresadola G. Hedwigia 53, 80, (1912).

sub *Daldinia concentrica* var *microspora* (Starb) Theiss.

Theissen F. Ann. Mycol. 7, 3, (1909).

sub *Daldinia corrugata* Pat. & Har.

Patouillard N. and P. Hariot. Bull. Soc. Myc. de Fr. 22, 120, (1906).

sub *Daldinia luzonensis* Rehm.

Rehm H. Philipp. J. Sci. 8, 260, 1913.

Stromata globose to pulvinate or hemispheric,  $5.0\text{--}38 \times 8.0\text{--}45 \times 5\text{--}23$  mm. Surface red-purple or red-brown, ectostroma refractive, deep orange but dark at sight, yielding yellow-orange vinaceous particles in microscopic section. Entostroma massive, brown, with alternating light and dark zones, the former predominating. Perithecia immersed, long ovate,  $400\text{--}700 \times 1000\text{--}1500\mu$ , close crowded; ostioles umbilicate sometimes raised above stroma level. Asci cylindric,  $145\text{--}310 \times 7\text{--}8\mu$ ; stipes  $83\text{--}230\mu$ . Spores elliptic equilateral or navicular, broad or narrow ended, dark brown to black,  $5.0\text{--}7.5 \times 11.0\text{--}16.5\mu$ , ave.  $6.3 \times 12.7\mu$ .

South African hosts: *Passerina falcifolia*. Mainly found in scrub or bush, not in heavy forest, unlike *D. concentrica*.

Material examined:—

Martin 419; Nature's Valley, Knysna District, Western Cape, South Africa (1958). Martin 642 ex Lowy; Baton Rouge, La., U.S.A., (1961). Martin 948; Mazatlán, Sinaloa, Mexico (1961). Martin 1795 ex Carroll 175; University of Costa Rica, San Pedro, Costa Rica, (1962).

Cultural characters (Plate V: 7; Plate VI: 7):—

Colonies felty to cottony, dull white, much denser and more compact than those of *D. concentrica*, growing freely with coarse texture; mycelial aggregates extensive. Conidia formed immediately but not conspicuous. Stain red-orange to greenish-brown, in fleck formation or fairly uniform. Growth rate rapid,  $8.7\text{--}10.5$  mm/day at  $25^{\circ}\text{C}$ .

Microscopic characters:—

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $3.0\mu$ . Secondary mycelium uniform, loose to reticulate-tentacular,  $1.1\text{--}4.4\mu$  diam.

Conidiophores and conidia (Fig. I: 7; Plate VIII: 1—3):—

Conidiophores sharply distinct from the vegetative mycelium, due to broader diameter, pitted walls and sometimes a reddish tint,  $30\text{--}650 \times 1.8\text{--}3.2\mu$ , unbranched or branched up to the second degree over most or part of the main axes with 2—4 fertile branches arising at a node. Fertile branches narrow or more usually swollen clavate, lying free or in trident formation with slightly swollen or unspecialized heads;  $8\text{--}40 \times 1.8\text{--}4.0\mu$ . Conidia acrogenous, acrogenous or in fascicles off the hyphae, sessile or borne on sterigmata, thin-walled, clavate, narrow-based, white to pink en masse,  $1.7\text{--}3.7 \times 3.4\text{--}6.3\mu$ , ave.  $2.3 \times 4.7\mu$ .

The species is distinct from *D. concentrica* by its smaller stromata and *Acrotaphylus* type conidiophores.

#### 4. *Daldinia bakeri* Lloyd.

Child M. Ann. Mo. Bot. Gard. 19, 464, (1932). Lloyd C. G. Myc. Writ. 5: Large Pyrenomycetes II, 25, (1919).

Stromata pulvinate,  $7.5-8.0 \times 11-16 \times 6.5-7.0$  mm, sessile or with ill-differentiated stipes  $4.5-6.5 \times 1.5-5.0$  mm. Surface of stroma wrinkled, reddish brown; ectostroma refractive, dark at sight but yielding vinaceous particles in microscopic preparation. Entostroma massive, with zones alternating in hue; dark zones predominant. Perithecia immersed, elliptic,  $300-500 \times 800-1000\mu$ , close crowded in palisade formation; ostioles invisible, Asci cylindric,  $165-325 \times 10-11\mu$ ; stipes  $75-105\mu$ . Spores gibbous, narrow ended, dark brown,  $6.0-8.0 \times 11.0-16.5\mu$ , ave.  $715 \times 15.0\mu$ .

Material examined:—

Martin 1818 ex Carroll 177; Coronado, Costa Rica, (1962).

Cultural characters (Plate VI: 3):—

Colonies cottony, dull white, growing freely with coarse texture; mycelial aggregates extensive; margin not distinct, hyphae widely dispersed. Conidia produced by 7 days but not conspicuous. Stain red-brown. Growth rate rapid,  $4.7$  mm/day at  $25^{\circ}\text{C}$ .

Microscopic characters:—

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $1.5\mu$ . Secondary mycelium reticulate-tentacular, uniform,  $2.5-3.7\mu$  diam.

Conidiophores and conidia (Plate VIII: 4):—

These conform to the *Sporothrix* type seen in *D. concentrica* and *D. occidentale*:  $260-330 \times 2.0-2.5\mu$ , branched to the first or second degree and branched dichotomously near the apices of the primary axes. Fertile branches narrow, lying freely, with unspecialized heads,  $15-42 \times 2.2-3.1\mu$ . Conidia acrogenous, on stout sterigmata, botuliform, ends sometimes truncate, white en masse,  $3.1-4.3 \times 5.6-6.3\mu$ , ave.  $3.7 \times 6.4\mu$ .

#### 5. *Daldinia vernicosa* (Schw.) Ces. & DN. (Plate IV: 6, 10, 11)

Cesati V. & G. de Notaris Comm. della Soc. Critt. Ital. 1, 198, (1863). Child M. Ann. Mo. Bot. Gard. 16, 411—486, (1929); Ibid. 19, 469, (1932). Cooke M. C. Handbook of Australian Fungi 292, (1892). Ellis, J. B. & B. M. Everhart Jour. Mycol. 4, 111, (1887); N. Amer. Pyren. 661, (1892). Lloyd C. G. Myc. Writ. 5, 604, (1916); Ibid. 5: Large Pyrenomycetes II, 25, (1919); Ibid. 7, 1203, (1923). Spegazzini C. Anal. Soc. Cient. Arg. 90, 173, (1920), (v. *microspora*) Starbäck K. Bih. Svenska Vet-akad. Handl. 27, 6, (1901). sub *Daldinia fissa* Lloyd. Lloyd C. G. Myc. Writ. 7, 1313, (1924).

sub *Hypoxylon vernicosum* (Schw.) Berk.

Berkeley M. J. Hooker's Jour. of Bot. 6, 226, (1854); Jour. Linn. Soc. 10, 384, (1869). Berkeley M. J. & M. A. Curtis Proc. Linn. Soc. Bot. 10, 384, (1867).

sub *Sphaeria cingulata* Lévl. Léveillé M. J. H. Ann. de Sci. Nat. Bot. 111, 3, 47, (1845). sub *Sphaeria vernicosa* Schw.



Currey F. Trans. Linn. Soc. Lond. **22**, 266, (1859). Durieu de Maisonneuve M. & J. F. C. Montagne Explor. Alger. I, 451, (1846). Schweinitz L. v. D. J. Acad. Nat. Sci. Philad. **5**, 9, (1825); Trans. Amer. Phil. Soc. Philad. NS. **4**, 190, (1832).

Stromata pulvinate,  $8.0-35 \times 12-36 \times 6-18$  mm, sessile or with ill differentiated stipes:  $2.5-9 \times 6-9$  mm. Outer layer wrinkled, yellow ochre; ectostroma refractive, dark at sight but yielding vinaceous particles in microscopic preparations. Entostroma massive, partly corky, carbonous and gelatinous, with several cavities present; in this way differing from other species of *Daldinia*. Zones of alternate colouration, not conspicuous and of equal prominence. Perithecia immersed, polystichous, long ovate,  $300-600 \times 800-1100\mu$ ; ostioles not visible. Asci cylindric, sporing part  $67-82 \times 9-10\mu$ . Spores elliptic, equilateral or gibbous, broad ended, dark brown to black,  $5.0-7.5 \times 10.0-14.0\mu$ , ave.  $6.6 \times 12.0\mu$ .

Material examined:—

Ellis & Everhart; (details absent), NYBG. Carroll 174; Payap, Thailand, (1958), (NYBG). Harper; on *Quercus*, Glencoe, Ill., U.S.A., (1902), (NYBG). Martin 891; culture ex C.B.S. (1961). Martin 1829 ex Kramer in Mycol. Herb Kansas 15; Leavenworth, Kansas, (1963). G. W. Martin & Weldon 8342; Panama, (1952), (NYBG).

Cultural characters (Plate VI: 4):—

Colonies silky to cottony, pure white, growing freely with a fine texture; mycelial aggregates extensive. Margin not distinct, entire; hyphae widely dispersed. Conidia formed by 7 days. Stain red brown, in fleck formation. Growth rapid,  $10.0$  mm/day at  $25^{\circ}\text{C}$ .

Microscopic characters:—

Primary mycelium undiagnostic; maximum diameter of marginal hyphae =  $2.3\mu$ . Secondary mycelium with irregular vesiculate swellings, reticulate-tentacular,  $1.8-2.8\mu$  in diameter.

Conidiophores and conidia (Plate VIII: 5—7):—

Conidiophores of the simple *Sporothrix* or *Nodulisporium* type:  $85-300 \times 1.2-2.5\mu$ , unbranched or branched dichotomously or ternately to the first degree near the top of the primary axes. Fertile branches smooth or geniculate, with unspecialized heads,  $7.5-26 \times 3.1-4.3\mu$ . Conidia pleuracrogenous or acrogenous, sessile or on stout sterigmata, oval or long clavate, white en masse,  $3.7-4.3 \times 5.6-8.8\mu$ , ave.  $4.1 \times 6.9\mu$ .

3. *Phylacia* Léveillé M. J. H. Ann. Sci. Nat. Bot. III, 3, 61, (1845).

This genus was founded in 1845 on the type species *P. globosa* Lév, and 5 members were subsequently added. The genus is unique in the Xylariaceae in that the asci have only been observed in one species, *P. turbinata*. Doubt has been expressed by many workers as to whether these fungi really represent





stromata or acervuli, but the writer concurs with Dennis (1957) in assuming that the elongate locules which are sometimes collapsed to form a hollow interior beneath the crust represent perithecia similar to those in *Camillea*, and that this view should be changed only on positive demonstration of the spores as conidia rather than ascospores.

Lloyd (1917) placed *Phylacia* as a subgenus of *Camillea*, but there are sharp differences between the two groups. *Camillea* usually lacks a definite ectostroma at maturity and the basal tissue is uniform, so that it can reasonably be merged with *Numulariola*. The structure of *Phylacia*, on the other hand, is actually the most complex in the Xylariaceae since differentiation of both ectostroma and antostroma occurs. When material is well preserved the stroma shows the following (See Plate I: 3, 4, 6, 10):—

1. an initial red brown or brown corky veneer, turning black with age—as in *Daldinia* and in *Hypoxylon*.
2. ectostroma brittle refractive, deep red or vinaceous at sight or on dissolving in acetone or alcohol.
3. entostroma well developed, at least  $\frac{1}{4}$  of the stroma height, carbonaceous externally and abruptly or gradually becoming corky beneath the perithecia. Often this basal tissue is white and not densely packed; thus resembling *Kretschmaria*.
4. presence of a stipe or some degree of ramification of the stroma.

*Phylacia* is distinct from all other Xylariaceae in these features, notwithstanding considerable variety in external form. The stromata are usually globose to turbinate, and when branched give rise to clavules of similar form (Plate I: 5). The number of perithecia is presumably always greater than one, and release of the spores in most cases takes place by decay of the upper crust rather than by dehiscence through ostioles (Plate I: 4, 6). Ostioles have only been observed by the writer in *P. globoso-turbinata*, and these are not clearly distinct. The spores are usually cylindric and amber in colour, showing little intra-specific difference, as in *Daldinia* (Plate I: 8, 9).

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PLATE I. Stromata in *Entonaema*, *Phylacia* and *Thamnomycetes*.

1—2. *Entonaema liquescens*; surface and side views ( $\times 0.75$ ). 3. *Phylacia poculiformis*; side view of “pepper-pot” stroma ( $\times 0.75$ ). 4. *Phylacia poculiformis*; surface view showing spore release by attrition of ectostroma, and absence of ostioles ( $\times 2.4$ ). 5. *Phylacia sagraeana*; surface view of multiclavulate stroma ( $\times 0.75$ ). 6. *Phylacia sagraeana*; surface enlarged to show ectostroma as in (4) and clustered perithecia beneath ( $\times 5$ ). 7. *Phylacia turbinata*; side view of stroma ( $\times 2.4$ ). 8. *Phylacia turbinata*; broad cylindric spores ( $\times 540$ ). 9. *Phylacia sagraeana*; narrow cylindric spores ( $\times 540$ ). 10. *Phylacia poculiformis*; longitudinal section of stroma showing massive entostroma, upper part carbonaceous surrounding elongate perithecia and basal part corky. Ectostroma is seen separating from the stipe below ( $\times 2.4$ ). 11. *Thamnomycetes rostratus*; part of fertile stipe ( $\times 5$ ). 12. *Thamnomycetes rostratus*; whole specimen ( $\times 0.4$ ).

## KEY TO THE SPECIES

1. Stromata branched, forming sessile clavulae in long linear or elliptic groups.....2
- 1'. Stromata usually simple though occasionally united and often aggregated.....4
2. Clavulae cylindric, apex flat, often truncate; spores  $5.5 \times 13.0\mu$   
*Phylacia surinamensis* (Berk. & Cke.) Dennis.....3
- 2'. Clavulae globose to ovoid, apex convex.....3
3. Clavulae  $2-3.5$  mm in diameter; spores  $4.5-6.0 \times 9.0-12.0\mu$   
*Phylacia sagraeana* (Mont.) Dennis.....3
- 3'. Clavulae usually exceeding 3 mm in diameter; spores  $4-8 \times 9-15\mu$   
*Phylacia globosa* Lévillé.....3
- 4 (1). Stromata definitely stipitate; clava globose at base then conic to form a gently sloping rounded apex; spores  $6.0-7.5 \times 10.5-13.5\mu$   
*Phylacia poculiformis* Montagne (Plate I: 3).....3
- 4'. Stromata sessile or indistinctly stipitate.....5
5. Stromata globular, single or united; spores  $6.5-7.0 \times 11.5-15.0\mu$   
*Phylacia bomba* (Mont.) Patouillard.....5
- 5'. Stromata obconic or turbinate.....6
6. Spores  $6.5 \times 13.5\mu$ ; ostioles many, indistinct to vaguely papillate; stromata obconic  
*Phylacia globoso-turbinata* Lloyd  
syn. *Camillea globoso-turbinata* Lloyd.....6
- 6'. Spores  $5.5-8.5 \times 11.5-14.0\mu$ , ostioles not apparent; stromata obconic to turbinate, flat topped or convex  
*Phylacia turbinata* (Berk.) Dennis.....6

1. *Phylacia sagraeana* (Mont.) Dennis (Plate I: 5, 6, 9)

Dennis R. W. G. Kew Bull. 1957, 324, (1957).

sub *Camillea sagraeana* (Mont.) Berk. & Curt.

Berkeley M. J. Jour. Linn. Soc. Bot. 10, 384, (1869). Ellis J. B. & B. M. Everhart N. Amer. Pyren. 663, (1892). Lloyd C. G. Myc. Writ. 5: Large Pyrenomycetes I, 7, (1917); Ibid. 7, 1281, (1924). Miller J. H. Monog. Univ. Puerto Rico B 2, 197, (1934). Rehm H. Hedwigia 28, 300, (1889). Rick J. Brotéria ser. bot. 25, 39, (1931). Theissen F. Ann. Mycol. 7, 7, (1909).

sub *Hypoxylon sagraeanum* Mont.

Currey F. Trans. Linn. Soc. Lond. 22, 264, (1859). Montagne J. F. C. in Sagra; Hist. Cuba, 343, (1838-1842); Ann. Sci. Nat. II, 17, 123, (1842).

Stromata ovoid to globose, indefinitely ramified with 4-100 clavulae, each  $2.0-3.5 \times 2.8-4.5 \times 3.1-9.0$  mm; apices flat to rounded or sometimes gently conic; stipes definite, smooth black,  $1.2-2.2 \times 3.0-4.5$  mm. Outer layer smooth, black; ectostroma refractive, black at sight but disintegrating into vinaceous particles on microscopic section. Entostroma massive, carbonous towards the exterior, basal tissue corky; solid, concolorous, dull brown to black. Perithecia immersed, about 40 per clavule, tightly packed, vertically oriented, long elliptic,  $300-400 \times 1,000-1,400\mu$ ; ostioles apparently absent. Asci not seen. Spores cylindric with parallel sides, amber, subhyaline to translucent, with prominent hyaline sheaths,  $4.5-7.0 \times 7.5-14.5\mu$ , ave.  $5.4 \times 10.7\mu$ .

Material examined:—

Martin 1516; San Blás, Mexico, (1962). Martin 1792 ex Carroll 170; Dominical, Costa Rica, (1962). Seaver in N.Y. Bot. Gard.: Plants of Trinidad, B.W.I., 3124; Matchepoorie, Trinidad, (1921), (NYBG). Weston; Barro Colorado Island, Panama, (1928), (AA).

Cultural characters:—

Colonies felty, appressed, uniform dull white; margin not distinct, lobed; hyphae lying compact. Stain olive green, conspicuous beneath mycelium, growth rapid, 4·5 mm/day at 25°C.

Microscopic characters:—

Primary mycelium undiagnostic; maximum diameter of marginal hyphae = 2·0 $\mu$ . Secondary mycelium uniform, reticulate, 3·0—6·0 $\mu$  diameter. Conidiophores and conidia: sterile.

2. *Phylacia turbinata* (Berk.) Dennis (Plate I: 7, 8)

Dennis R. W. G. Kew Bull. 1957, 324, (1957).

sub *Camillea turbinata* (Berk.) Speg.

Ellis J. B. & B. M. Everhart Bull. Lab. Nat. Hist. Univ. Iowa 2, 411, (1893). Von Hohnel F. Denkschr. Akad. Wiss. Wien. Math. naturw. Klasse 83, 26, (1927). Lloyd C. G. Myc. Writ. 5: Large Pyrenomycetes I, 4, (1917); Ibid. 7, 1280, (1924). Rick J. Brotéria ser. bot. 25, 36, (1931). Spegazzini C. Bol. Acad. Nat. Cienc. Cordoba 11, 509, (1889). Starbäck K. Bit. Svenska vet. abad. Handl. 27, IX, 4, (1901) (var. *obpatellata*). Theissen F. Ann. Mycol. 7, 7, (1909). Viégas A.P. Bragantia 4, 99, (1944).

sub *Hypoxyton turbinatum* Berk.

Berkeley M. J. Jour. Linn. Soc. 15, 51, (1876).

Stromata stipitate with one or two ovoid to pulvinate fertile heads, sometimes resembling pepper pots, 5·3—7·5  $\times$  5·5—10·5  $\times$  5·5—7·5 mm; stipes ill differentiated or distinct, 2·5—6·0  $\times$  1·3—6·5 mm. Outer layer on clavata in the form of polygonal crusts, reddish brown; ectostroma refractive, dark at sight but yielding rose red particles in microscopic preparations. Entostroma massive, corky at base becoming rigid or carbonaceous towards the exterior. Perithecia immersed, tightly packed, ovate, 800—900  $\times$  1000  $\times$  1200 $\mu$ ; ostioles apparently absent. Asci not seen; quoted by Dennis as globose, 29—42  $\times$  12—15 $\mu$ ; stipes 5—7 $\mu$ . Spores cylindrical, amber, subhyaline to translucent, 5·0—10·0  $\times$  8·5—16·5 $\mu$ , ave. 7·6  $\times$  12·7 $\mu$ .

Material examined:—

Digilio Grassi in Herb. Inst. Miguel Lillo 5596; Urundel Salta, Argentina, (1961) (NYBG). Martin 901 ex Schroeder; Petén, Guatemala, (1961). Martin 1508, 1517, 1567; San Blás, Nayarit, Mexico, (1962). Smith; Mexico, (1895), (NYBG).

Cultural characters:—

Colonies canescent to felty, dry, appressed, lobed; margin not distinct, hyphae compact, colourless. Stain very prominent: yellow, amber, or olive green. Growth rate moderate, 3·6 mm/day at 25°C.

Microscopic characters:—

Primary mycelium undiagnostic; maximum diameter of marginal hyphae = 1·5 $\mu$ . Secondary mycelium uniform, loose to reticulate, 1·2—2·5 $\mu$  diam. Conidiophores and conidia:— Sterile.



1. *Thamnomycetes* Ehrenberg C. G. Hortae Physicae Berolinenses 79, (1820). (See also Lloyd C. G. Mycol. Writ. 6, 904—944, (1920)).

This genus comprises 5 species in which the stroma is elongate, dendroid and usually branched. The form is quite distinct from *Phylacia* but is definitely related to it in structural features (Plate I: 11, 12). The ectostroma is corky or brittle-refractive and pigmented, bearing a brownish-red or purple veneer when young. The entostroma surrounding the perithecia and often beneath them is relatively massive, rigid and carbonaceous, while that in the centre of the stroma is softer, corky and dark brown, not apparently turning white as in *Phylacia*. The perithecia are remarkable in that they are either enclosed in apical clavules (sub-gen. *Scopimycetes*) or are clearly evident in outline and arise from the sides of the stipes. This condition is a clear parallel to that in *Kretzschmaria* and *Xylaria*.

#### KEY TO THE SPECIES

1. Stromata dichotomously branched; perithecia embedded in the apices (sub genus *Thamnomycetes* Henn.) .....2
- 1'. Stromata little branched, bearing long beaked perithecia scattered along the axis. (sub genus *Scopimycetes* Henn.) .....4
2. Clavulae uniperitheciate. ....3
- 2'. Clavulae with more than 1 perithecium; spores  $4.0 \times 8.0\mu$   
*Thamnomycetes dendroidea* Cke. & Massee
3. Spores  $4.0 \times 7.5\mu$   
*Thamnomycetes chamissonis* Ehrenberg
- 3'. Spores  $6-8 \times 13-19\mu$   
*Thamnomycetes camerunensis* Hennings
- 4 (1) Axis less than 1 mm thick; perithecia sessile; ascospores  $3.5 \times 7.5\mu$   
*Thamnomycetes rostratus* Montagne (Plate I: 11, 12)
- 4'. Axis 1—2 mm thick; perithecia short-stalked; ascospores  $4.5-5.5 \times 11-12\mu$   
*Thamnomycetes fuciformis* Berkeley.

No material has been found yet to yield cultures.

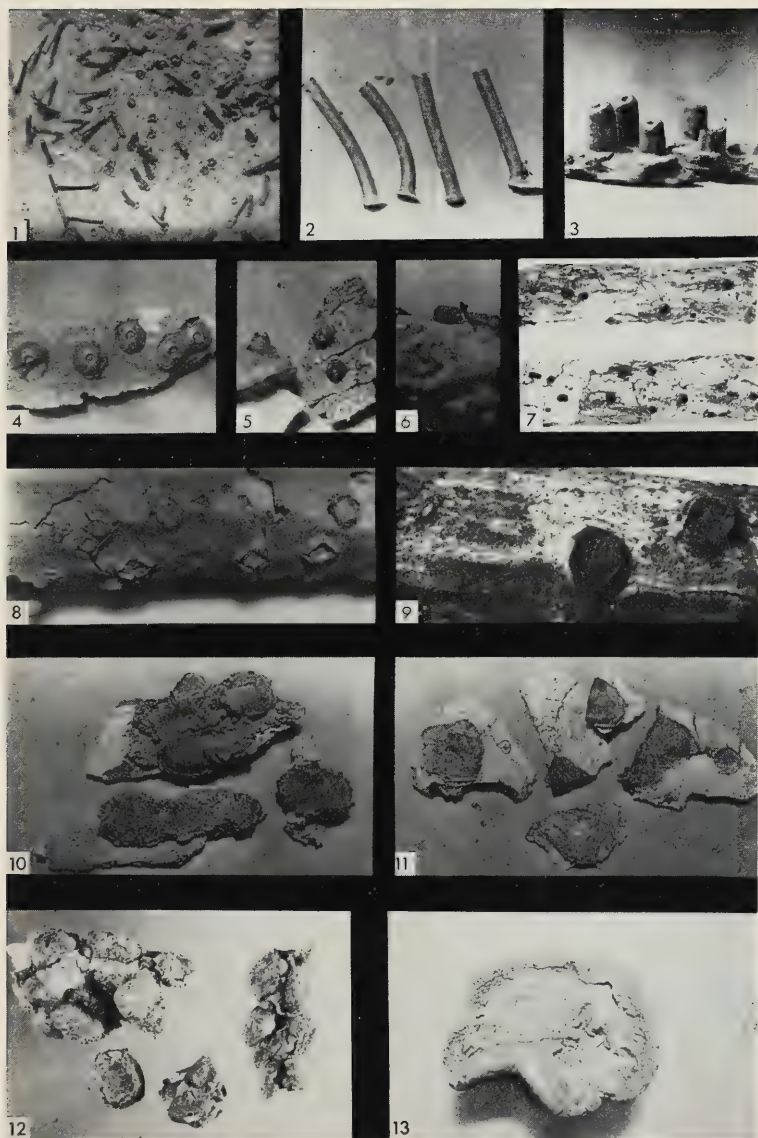
Series II. *Numulariola* House H. D. N.Y. State Museum Bull. 266, 49, (1925).

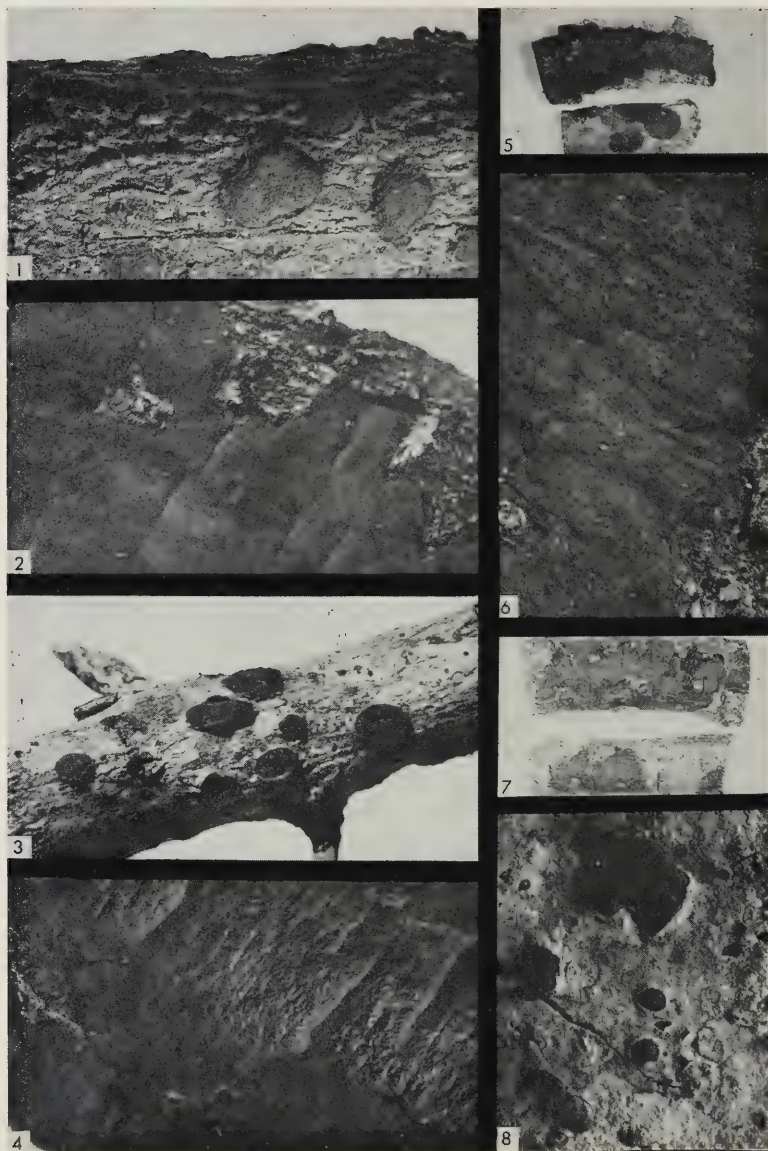
This genus was erected by House with scant definition of its limits. In the writer's opinion (Martin, 1967) the genus should include as well as the original species, species of other erumpent genera formerly considered quite distinct. Although erumpent species occur sporadically in diverse groups, there is nevertheless a sufficiently strong and widespread correlation between erumpent

#### PLATE II. Stromata in *Numulariola*.

1. *Numulariola (Camillea) bacilla* ( $\times 1.25$ ). 2. *Numulariola (Camillea) leprieurii* ( $\times 1$ ). 3. *Numulariola (Camillea) mucronata* ( $\times 1$ ). 4. *Numulariola (Camillea) macromphala* showing transition from cylindric to aplanate form ( $\times 1$ ). 5. *Numulariola (Camillea) cyclops*: form resembling *N. discreta* and relatives ( $\times 1$ ). 6, 8. *Numulariola discreta*: side and surface views of short cylindric stromata ( $\times 1$ ). 7, 9. *Numulariola kalchbrenneri* ( $\times 0.3$ ) and ( $\times 2$ ). 10. *Numulariola repanda* ( $\times 0.9$ ). 11. *Numulariola signata*. Note scaling off of ectostroma at left ( $\times 0.9$ ). 12. *Numulariola polysperma* ( $\times 1.25$ ). 13. *Numulariola (Peridoxylon) petersii*. Note thick ectostroma persistent at margin ( $\times 0.9$ ).







development, lack of pigment, aplanate or cylindric form, complete immersion and close packing of perithecia and potential involvement of the ectostroma with the substrate that the combination of these should override the relatively unimportant characters selected to establish several small genera, and serve as the basis of a single inclusive genus. These small genera deserve a brief review.

1. *Nummularia* Tulasne L. & C. *Selecta Fungorum Carpologia* II, 319, (1863). See Plate II: 6—9; Plate III: 3.

This was established by Tulasne and based on *N. discreta* (Schw.) Tul., which had a small cupulate stroma with a concave surface. According to Tulasne, the other chief characteristic was the innate formation of conidia between the stroma and bark. This was not completely explained, and later workers often did not understand what was meant. It was certainly ignored in the delimitation of other genera such as *Camarops* and *Camillea*. Consequently, the first feature has been the most widely discussed. Miller (1932, p. 131) and Shear (1938) did not consider *Nummularia* to be far from *Hypoxylon*, and Miller transferred back to *Hypoxylon* many species, e.g., *N. mediterranea* (DN.) Sacc., that were effuse and flattened and which had been previously placed in *Nummularia*. Miller's emendation of *Nummularia* to include cupulate forms only while retaining the diffuse ones in *Hypoxylon*, was, however, unsatisfactory since it evaded the manner of development.

Another more serious difficulty against the retention of *Nummularia* as a generic name was the fact that *Nummularia* Tul. was preceded by the angiosperm genus *Nummularia* Riv. ex Rupp (1745) and by its synonym *Nummularia* Gilib. (1781).<sup>\*</sup> Although *Nummularia* is now placed in synonymy with *Lysimachia* (Primulaceae), the name is not available for the fungal genus.

2. The Applanata group of *Hypoxylon* Miller J. H. *World Species of Hypoxylon*, 100, (1961). See Plate III.

The Applanata section was erected by Miller for the large number of effuse erumpent species formerly placed in *Nummularia* by workers subsequent to Tulasne. The writer does not consider that they have much affinity with the type species of *Hypoxylon*, *H. fragiforme* (Pers. ex Fr.) Kickx and other representative species, because the latter lack the peculiar combination of characters just discussed which are present in the Applanata group. On critical examination

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PLATE III. Stromata in *Numulariola* continued.

1, 2, 3, 4, 6, 8 ( $\times 2$ ). 5, 7 ( $\times 0.3$ ).

1. *Numulariola microplaca*. 2. *Numulariola uni-apiculata*. 3. *Numulariola exutans*; restricted elliptic form. 4. *Numulariola nummularia*. 5. *Numulariola mediterranea*. 6. *Numulariola mediterranea*. 7. *Numulariola uni-apiculata*. 8. *Numulariola merrillii*.

<sup>\*</sup> J. D. Hooker and B. D. Jackson, *Index Kewensis*, II, 320, Clarendon Press, Oxford, 1895.



many species show intergrades from the effuse to the cupulate form of stroma reserved for *Nummularia*. Several have extended ostiolar necks characteristic of *N. discreta*.

3. *Camarops* Karsten P. A. Mycologia Fennica II, 6 & 53, (1873). See Plate II: 12; Plate IV: 12.

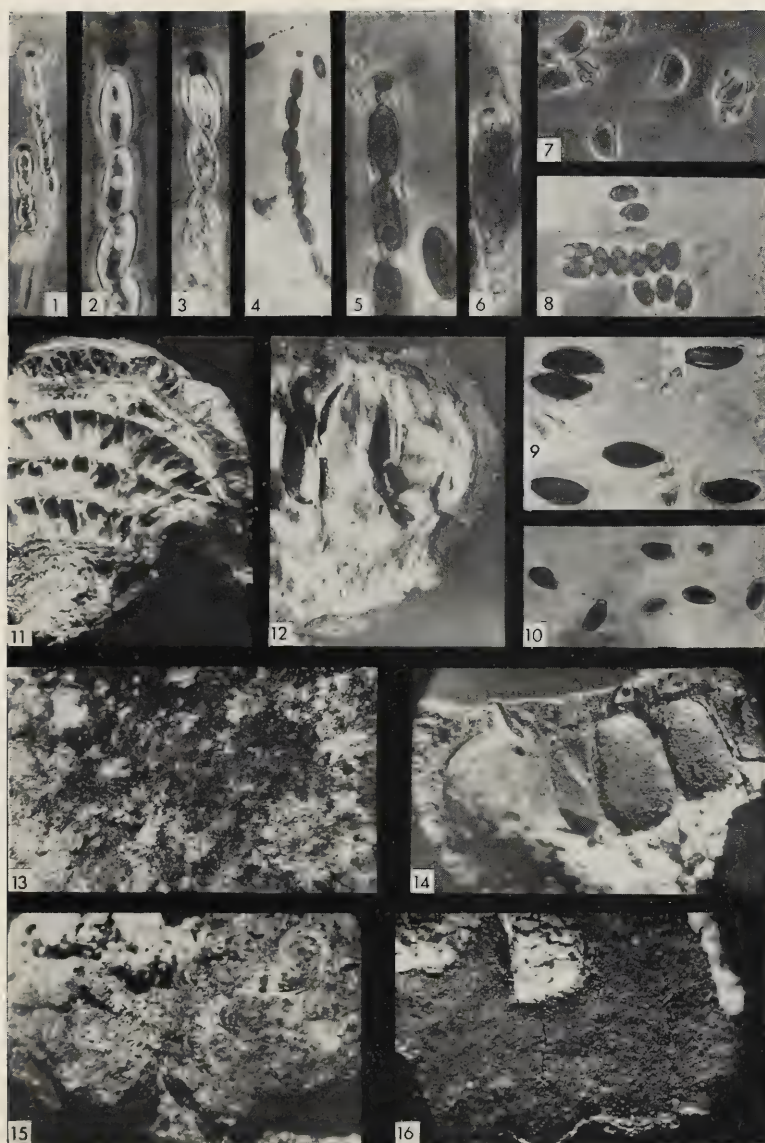
The genus *Camarops* was based on the single species *C. hypoxyloides* Karsten. The structure is patently similar to that in the *Applanata* section but the perithecia are elongate, subcylindric to tubuliform. The original description which states that the spores are spuriously septate is in error, and that character must be discarded. Two other species, *C. polyspermum* (Mont.) Miller (1930) and *C. microsporum* (Karst.) Shear (1938) are now included. The perithecia are tubular in the first species but ovate in the latter. Tubular perithecia occur in other unrelated species, e.g., *Hypoxyylon haematostroma* Mont. and *H. jecorinum* Berk. and Rav. (sect. *Euhypoxyylon*), and also in the next erumpent genus *Camillea*, so it can hardly be used as a character of generic value. On the other hand, the erumpent nature and general stromal features clearly relate it to the *Applanata* section and to *Nummularia*.

4. *Camillea* Fries E. M. Summa Veg. Scand. 382, (1849). (See also Lloyd C. G. Myc. Writ. 5: Large Pyrenomycetes I, 2, (1917)).

This genus is hard to separate from the cupulate forms of *Nummularia* since there are several of the latter (*N. broomeiana* (B. & C.) Mill., *N. artocreas* (Masse) Mill.) which are partly raised above the substrate level. The latter feature together with the tubular perithecia are, however, constant in the small number of species placed under *Camillea*. In form the stroma ranges from pulvinate-cylindric (*C. cyclops* Mont.) to elongate cylindric and rod-shaped in which the entostroma beneath the perithecia is linearly developed (*C. lepreurii*

#### PLATE IV.

1—6. Ascus structure. 1. *Numulariola tinctor* ( $\times 210$ ). 2. *Numulariola tinctor* ( $\times 540$ ); showing elongate composite ascal plug. 3. The same; showing horizontal division within ascal plug. 4. *Numulariola merrillii* ( $\times 210$ ). 5. *Numulariola merrillii* ( $\times 540$ ); normal discal plug. 6. *Daldinia vernicosa* ( $\times 540$ ); narrow plug at apex of dehiscing ascus. 7—10. Spore types. 7. *Numulariola bacilla*; broad crescentic ( $\times 540$ ). 8. *Numulariola polysperma*; obconic, with narrow proximal ends ( $\times 540$ ). 9. *Numulariola pithodes*; elliptic spores (cf fig. 5) each with proximal appendage or truncate end ( $\times 210$ ). 10. *Daldinia vernicosa* gibbous ( $\times 210$ ). 11—16. Details of stroma. 11. *Daldinia vernicosa*; vertical section through stroma showing ectostroma, polystichous perithecia, zonate entostroma with cavities and corky gelatinous matrix ( $\times 20$ ). 12. *Numulariola polysperma*; vertical section showing carbonous entostroma, elongate perithecia and corky basal tissue ( $\times 10$ ). 13. *Numulariola tinctor*; ectostroma (light) worn away to reveal papillate ostioles and carbonaceous entostroma beneath ( $\times 10$ ). 14. *Numulariola repanda*; vertical section through stroma showing perithecia and carbonous entostroma above, basal tissue below ( $\times 20$ ). 15. *Numulariola polysperma*; ostioles indistinct or raised umbilicate ( $\times 5$ ). 16. *Numulariola sinuosa*; prominent umbilicate ostioles in entostroma ( $\times 2$ ).





Mont., *C. bacillum* (Mont.) Sacc.). It is difficult to speak of a "stipe", however, because there is no clear outward differentiation between the fertile and sterile portions such as occurs in *Xylaria* and *Kretzschmaria*.

In development the stroma grows between the bark and the wood and ruptures the former in such a manner that it falls away without trace, leaving it apparently superficial. In all the species examined except *C. bacillum* the outer layer disappears in the process so that the shiny surface of the carbonous entostroma is exposed to view. *C. bacillum* differs from the others in persistence of a thin slate grey corky ectostroma and in a convex rather than concave apical portion, both features being typical of the Applanata section. *Camillea* also exhibits a wide range of spore shape. Thus there is no clear basis for the erection of this genus.

5. *Theissenia* Maublanc A. Bull. Myc. Soc. de France, **30**, 48—53, (1914).

This is a monotypic genus comprising *Theissenia pyrenocrata* (Theiss.) Maubl. Theissen originally placed this in *Ustulina* from which it was removed because of its erumpent development. As it stands, it is unsatisfactory because of the almost complete lack of definition, since it was based in part on superficial characters such as the large size of the perithecia and partly on the reported gelatinous nature of the tissue between the perithecia. The writer finds that the material in the New York Botanical Garden Herbarium and in the Miller Herbarium corresponds to the Applanata section in general characters, and that there are no grounds for erection of a distinct genus.

6. *Peridoxylon* Shear C. L. Mycologia **15**, 126, (1923). See Plate II: 13.

This is another monotypic genus. The stroma is large repand, and varies from being evenly attached to cupulate and indistinctly stipitate. From the material examined of *P. petersii* (B. & C.) Shear in the New York Botanical Garden Herbarium the stroma appears to be erumpent in most cases but it is difficult to find out whether this is always so. In other respects the structure is similar to *Camarops*, with elongate perithecia and ostiolar necks.

7. *Bolinia* Nitschke T. Pyrenomycetes Germanici 26, (1867).

This genus was founded by Nitschke for the polystichous species of *Nummularia*, the type being *B. tubulina* (A. & S.) Nits. ex Shear. The polystichous character is not a sound choice since it is also present in various unrelated species of *Hypoxylon* (*H. rubiginosum* Pers. ex. Fr., *H. novemexicanum* Mill.) and has little value for creation of a major taxon.

The writer proposes a single generic name to cover all the groups outlined. There are three synonyms of *Nummularia* available: *Biscogniauxia* Kuntze (1891), *Kommamyce* Nieuwland (1916), and *Numulariola* House (1925). The latter is selected because it was described to cover both the type of the genus

*Nummularia*, *N. discreta* (Schw.) Tul. and the type of the *Applanata* section of *Hypoxylon*, *Hypoxylon nummularium* Bull. ex Fr. The other generic titles referred only to *Hypoxylon nummularium* or its synonym *Nummularia bulliardi* Tul. and were not made applicable to the cupulate forms. The following characters appear to be basic to *Numulariola*, even though they may not all have been previously recognized:

- a. erumpent development, but with the ectostroma involved with the outer layer of the substrate and only partially retained at maturity, if at all. (In the other genera, the ectostroma of erumpent species is found to be separate from the substrate). (See Plate IV: 13);
- b. aplanate, discoid, cylindric to tubular form of stroma;
- c. surface of stroma varying from convex to concave, sometimes within the same species; concave stromata are rare elsewhere;
- d. ostioles varying from papillate to umbilicate, partly depending on the degree of erosion of the ectostroma which can mask papillate ostioles beneath. (See Plate II: 9; Plate III; Plate IV: 13, 15, 16)
- e. development of a sterile stroma margin in a proportion of the species
- f. rigid black "carbonous" entostroma surrounding the perithecia, becoming corky in texture basally (See Plate IV: 12, 14);
- g. closely packed perithecia of variable form;
- h. discoid ascus plugs (Plate IV: 1—5); this feature is almost constant in all the species where asci were found and directly relates the genus to *Lopadostoma*, but *Lopadostoma* is considered separate because of its valvoid structure;
- i. Spores elliptic to oval or subglobose; when inequilateral the germ slit is on the least convex side, in contrast to *Hypoxylon* except for the section *Entoleuca*. (See Plate IV: 14, 7—9)

#### KEY TO THE SPECIES

1. Stroma cylindric or tubular, at least 3 mm high above the substrate surface .....2  
..... (section *Camillea* Mont.)
- 1'. Stroma aplanate to short cylindric, or irregular in form; if greater than 3 mm high above the substrate, then not tubular .....7  
..... (Section *Innata*)
2. Stroma tubular to rod-shaped, narrow, at least 4 times as long as wide .....3
- 2'. Stroma short cylindric, sometimes decussate .....5
3. Stroma with concave upper surface surrounding a single central mucronate ostiole; spores not available .....5  
..... *Numulariola mucronata* (Mont.) Martin (Plate II: 3)  
..... syn. *Camillea mucronata* Montagne
- 3'. More than ostiole present; papillate to indistinct .....4

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\*Decimal figures represent averages of at least 10 spores; integers mere range of dimension

4. Stroma with concave upper surface, rimose, with ostioles close to the margin; upper part of stroma bluish white and base darker; spores obconic with proximal end narrow, amber,  $7.0 \times 15.0\mu^*$   
*Numulariola lepieurii* (Mont.) Martin (Plate II: 2)  
 syn. *Camillea lepieurii* Montagne
- 4'. Stroma with concave upper surface, ostioles central, outer layer (ectostroma) dull brown, uniform; spores oval-elliptic, crescentic, broad-ended, medium brown,  $4.0 \times 7.0\mu$   
*Numulariola bacilla* (Mont.) Martin (Plate II: 1, Plate IV: 7)  
 syn. *Camillea bacillum* (Mont.) Saccardo
5. (2) Margin rimose but simple..... 6
- 5'. Margin rimose and recurved at opposite ends to form two claw-like projections; spores elliptic, equilateral, broad-ended, amber,  $3.0 \times 8.0\mu$   
*Numulariola bilabiata* (Speg.) Martin  
 syn. *Camillea bilabiata* Spegazzini
6. Sides of stroma vertical; one fruiting portion only per stroma; spores cylindric, amber,  $3.5 \times 7.0\mu$   
*Numulariola cyclops* (Mont.) Martin (Plate II: 5)  
 syn. *Camillea cyclops* Montagne
- 6'. Sides of stroma decussate; one to 3 fruiting portions per stroma (stroma aplanate in latter case); spores cylindric, amber,  $5.0 \times 9.0\mu$   
*Numulariola macromphala* (Mont.) Martin (Plate II: 4)  
 syn. *Camillea macromphala* Montagne
7. (1) Perithecia polystichous..... 8
- 7'. Perithecia monostichous..... 10
8. Spores obconic, proximal end narrow, pale brown..... 9
- 8'. Spores with both ends similar; stroma erumpent through fissures in the bark, without sterile margin; basal tissue scanty; spores dark brown to black,  $4.5 \times 9.5\mu$   
*Numulariola obscura* Martin nov. sp.
9. Stroma with pronounced sterile margin, usually partly covered by substrate at maturity; basal tissue well developed; spores  $3.5 \times 6.0-6.5\mu$   
*Numulariola lutea* (A. & S. ex Fr.) Martin  
 syn. *Bolinia lutea* (A. & S. ex Fr.) Miller  
*Nummularia lutea* (A. & S. ex Fr.) Nitschke
- 9'. Stroma fertile at the margins, without substrate covering; basal tissue scanty; spores  $2.5-3.0 \times 4.5-6.0\mu$   
*Numulariola tubulina* (A. & S. ex Fr.) Martin  
 syn. *Bolinia tubulina* (A. & S. ex Fr.) Saccardo  
*Camarops tubulina* (A. & S.) Shear  
*Hypoxyton tubulium* (A. & S. ex Fr.) Fries  
*Nummularia tubulina* (A. & S. ex Fr.) Miller
10. (7) Spores obconic, proximal end narrow..... 11
- 10'. Spores with both end similar; or if different then spores elliptic..... 13
11. Ascospores amber to colourless  $3.5-5.0 \times 7.0-9.0\mu$ ; stromata normally less than 1 mm in height, aplanate, effuse  
*Numulariola punctulata* (B. & Rav.) Martin  
 syn. *Hypoxyton punctulatum* (B. & Rav.) Cooke
- 11'. Ascospores some shade of brown; stromata normally exceeding 3 mm in height. . 12
12. Stroma large, broadly exposed, aplanate—repand to broad cupulate, with soft thick ectostroma that sloughs off at maturity; perithecia ovate; basal tissue well developed, dull brown; spores medium brown,  $4.5 \times 7.0\mu$   
*Numulariola petersii* (Lloyd) Martin (Plate II: 13)  
 syn. *Hypoxyton petersi* Lloyd  
*Peridoxyton petersi* (Lloyd) Shear
- 12'. Stroma of medium size, often covered by substrate, cylindric or oval, aggregated; ectostroma slight; perithecia elongate, basal tissue varying in development; spores pale to medium brown,  $3.0-4.5 \times 5.0-8.5\mu$   
*Numulariola polysperma* (Mont.) Martin (Plate II: 12)  
 syn. *Camarops polyspermum* (Mont.) Miller  
*Hypoxyton atroviride* Ellis & Everhart

13. (10) Spores appendiculate, some shade of brown; appendiculus often evanescent leaving truncate proximal spore end ..... 14
- 13'. Spores not appendiculate, amber or brown to black ..... 21
14. Ostioles punctate, each at the base of a depression; ectostroma brown ..... 15
- 14'. Ostioles minutely punctate-umbilicate or papillate, not below stroma level; ectostroma in various shades; dull brown, grey or greenish-grey at maturity ..... 17
15. Perithecia elongate,  $120-140 \times 250-350\mu$ ; spores cylindric-elliptic with broadly rounded distal ends,  $5-6 \times 10-14\mu$   
*Numulariola doidei* (Mill.) Martin  
 syn. *Hypoxylon doidei* Miller
- 15'. Perithecia globose or ovate to oblong compressed,  $300-400 \times 300-700\mu$ ; spores elliptic with narrow rounded distal ends ..... 16
16. Spores  $7.0 \times 8.0-6.5 \times 12.5\mu$  (excluding apiculus)  
*Numulariola grenadense* (Mill.) Martin  
 syn. *Hypoxylon grenadense* Miller
- 16'. Spores  $8.5 \times 15.5\mu$   
*Numulariola grenadense* var. *macrospora* Miller
17. (14) Ostioles papillate or inconspicuous, spores narrow-ended ..... 18
- 17'. Ostioles minutely punctate-umbilicate; ectostroma dull brown to greenish-grey; perithecia with tubular ostiolar necks; spores elliptic, equilateral to navicular, normally broad ended,  $5.0-7.7 \times 9.5-13.0\mu$   
*Numulariola uniapiculata* (P. & S.) Martin  
 syn. *Hypoxylon uniapiculatum* (P. & S.) Miller  
*Nummularia uniapiculata* Penzig & Saccardo
18. Ectostroma grey; perithecia with tubular ostiolar necks; spores gibbous,  $11.5 \times 25.5\mu$   
*Numulariola philippinense* (Ricker) Martin  
 syn. *Hypoxylon philippinense* (Ricker) Miller  
*Nummularia philippinense* Ricker
- 18'. Ectostroma dull brown; perithecial necks short ..... 19
19. Basal tissue beneath perithecia well-developed, more than  $\frac{1}{4}$  the height of the stroma; ostioles papillate; spores gibbous to navicular,  $11.0-13.0 \times 21.5-27.0\mu$   
*Numulariola pithodes* (B. & Br.) Martin  
 syn. *Hypoxylon pithodes* (B. & Br.) Miller  
*Nummularia pithodes* (B. & Br.) Cooke
- 19'. Basal tissue beneath perithecia not conspicuous, ostioles indistinct or medium papillate ..... 20
20. Spores equilateral to gibbous,  $7.5 \times 17.0\mu$   
*Numulariola divergens* (Theiss.) Martin  
 syn. *Hypoxylon divergens* (Theiss.) Miller  
*Nummularia divergens* Theissen
- 20'. Spores gibbous,  $11.5 \times 21.0\mu$   
*Numulariola divergens* var. *macrospora* Miller
21. (13) Spores amber to yellow, or nearly colourless, hyaline to subhyaline ..... 22
- 21'. Spores pale to dark brown or black ..... 38
22. Basal tissue beneath perithecia well developed, more than  $\frac{1}{4}$  the height of the stroma ..... 23
- 22'. Basal tissue slight, less than  $\frac{1}{4}$  the height of the stroma ..... 24
23. Stroma short cylindric, often produced above the wood surface, with distinct warty-verrucose sides; surface of stroma concave; spores navicular, acute-pointed,  $4.5 \times 13.5\mu$   
*Numulariola labella* (Mont.) Martin  
 syn. *Nummularia artocreas* (Cke. & Mass.) Miller  
*Camillea labellum* Montagne
- 23'. Stroma aplanate, circular to variably effuse, at substrate level or slightly raised, in which case the sides are smooth; surface convex to concave; spores elliptic equilateral to navicular,  $4.5-8.5 \times 10.0-21.0\mu$   
*Numulariola broomeiana* (B. & C.) Martin  
 syn. *Hypoxylon broomeianum* Berkeley & Curtis  
*Nummularia broomeiana* (B. & C.) Miller



24. (22) Perithecia long elliptic to tubular, at least 5 times as long as broad; spores elliptic equilateral, broad-ended,  $3.0 \times 5.5\mu$   
*Numulariola hypoxyloides* (Karst.) Martin  
 syn. *Camarops hypoxyloides* Karsten
- 24'. Perithecia ovate to elongate elliptic but less than 4 times as long as broad.....25
25. Ostioles sulcate with long dorsal decussate grooves, radiating over surface of aplanate stroma; spores gibbous to navicular, narrow-ended  $8.5 \times 22.0\mu$   
*Numulariola sulcata* (Starb.) Martin  
 syn. *Hypoxylon sulcatum* Starbäck
- 25'. Ostioles horseshoe-shaped, wide sulcate but not elongate.....26
- 25". Ostioles entire or not visible.....27
26. Ostioles at stromal level, elliptic, spores fusoid,  $6.5 \times 13.0\mu$   
*Numulariola heterostoma* (Mont.) Martin  
 syn. *Hypoxylon heterostomum* Mont.
- 26'. Ostioles in depressions, spores  $8-10 \times 25-30\mu$   
*Numulariola heterostoma* var. *macrospora* Miller
27. (25) Perithecia in definite groups in the stroma, separated by sterile tissue, or occupying centre of stroma and surrounded by wide sterile margin.....28
- 27'. Perithecia continuous throughout and margin very narrow if present.....32
28. Stroma aplanopulvinate to cylindric, raised above substrate level; perithecia in circular groups, opening into as many pits in the surface of the stroma; spores elliptic equilateral, broad-ended,  $5.0 \times 9.0\mu$   
*Numulariola macromphala* (Mont.) Martin (Plate II: 4) (effused form)  
 syn. *Camillea macromphala* (Mont.) Cke.
28. Stroma aplanate, at substrate level.....29
29. Perithecia in small valsoid groups, spores elliptic, equilateral to gibbous, proximal ends narrow,  $5.0 \times 11.5\mu$   
*Numulariola flosculosa* (Starb.) Martin  
 syn. *Hypoxylon flosculosum* (Starb.) Miller
- 29'. Perithecia dispersed, in irregular groups, or grouping not apparent.....30
30. Ostioles umbilicate with raised rim, each sunken in a superficial depression; spores navicular, with narrow ends, smooth,  $7.5 \times 27.0\mu$   
*Numulariola scriblita* (Mont.) Martin  
 syn. *Hypoxylon scriblita* Montagne
- 30'. Ostioles umbilicate with raised rim, level with stroma surface; spores rough-walled, elliptic equilateral to gibbous, with broad or narrow ends,  $5.0-7.5 \times 11.5-19.5\mu$   
*Numulariola comedens* (Ces.) Martin  
 syn. *Hypoxylon comedens* Cesati
- 30". Ostioles without raised rim, spores smooth.....31
31. Ostioles umbilicate, surrounded by ectostromal remnants that superficially appear as rough truncate discs; spores gibbous, narrow ended,  $5-7 \times 14-20\mu$   
*Numulariola melanaspis* (Mont.) Martin  
 syn. *Hypoxylon melanaspis* Montagne
- 31'. Ostioles indistinctly papillate; not sunken or with raised margins; ectostroma slight and entostromal surface characteristically shiny; spores equilateral elliptic to cylindric, narrow-ended,  $5-7 \times 14-24\mu$   
*Numulariola cyclicis* (Mont.) Martin  
 syn. *Hypoxylon cyclicum* Montagne
32. (27) Spores small, not exceeding  $10\mu$  long.....33
- 32'. Spores exceeding  $10\mu$  in length.....35
33. Stromata large, irregular, effuse; ostioles clearly narrow punctate-umbilicate; spores equilateral elliptic to cylindric, broad-ended or sometimes obconic; colourless to amber,  $3.5-5.0 \times 7.0-9.0\mu$   
*Numulariola punctulata* (B. & Rav.) Martin  
 syn. *Hypoxylon punctulatum* (B. & Rav.) Cooke
- 33'. Stromata usually restricted in extent, orbicular; ostioles umbilicate and rather wide mouthed or indistinctly papillate or annulate papillate; spores elliptic to cylindric broad-ended, amber to pale brown,  $3.0 \times 5.5-2.5 \times 7.0\mu$   
*Numulariola microplaca* (B. & C.) Martin  
 syn. *Hypoxylon microplacum* (B. & C.) Miller



- 33'. Ostioles not umbilicate ..... 34
34. Ostioles prominent, tubular; spores cylindric, amber,  $2.5 \times 5.0\mu$   
*Numulariola microspora* (Karst.) Martin  
 syn. *Anthostoma microsporum* Karsten  
*Camarops microsporum* (Karst.) Shear
- 34'. Ostioles papillate to indistinct, stroma irregularly erumpent, sometimes linear; entostroma surface shiny black; spores cylindric, amber,  $2.5 \times 5.0\mu$   
*Numulariola helvetica* (Nits.) Martin  
 syn. *Nummularia helvetica* (Nits.) Miller
35. (32) Perithecia large, globose to elongate or compressed, 1,800—4,900 $\mu$  wide and 300—4,500 $\mu$  high; spores elliptic equilateral, broad-ended or narrow-ended,  $5.5-8.0 \times 16.0-17.0\mu$   
*Numulariola pyrenocrata* (Theiss.) Martin  
 syn. *Theissenia pyrenocrata* (Theiss.) Maublanc
- 35'. Perithecia smaller, not exceeding 1,500 $\mu$  in diameter. .... 36
36. Stromata strictly circular to oval, less than 6 mm. in length or diameter; ostioles not visible, at stroma level; spores gibbous, acute-ended,  $4.0 \times 14.0\mu$   
*Numulariola venezuelensis* (Mill.) Martin  
 syn. *Nummularia venezuelensis* Miller
- 36'. Stromata circular to effuse, ostioles umbilicate or papillate ..... 37
37. Ostioles umbilicate with raised margins; spores navicular to crescentic, narrow-ended,  $7.5-8.5 \times 24.0-29.0\mu$   
*Numulariola glycyrrhiza* (B. & C.) Martin  
 syn. *Hypoxylon glycyrrhiza* Berkeley & Curtis
- 37'. Ostioles umbilicate or papillate depending on erosion of the brown ectostroma; spores equilateral to navicular, narrow-ended,  $6.5-8.5 \times 14.5-20.5\mu$   
*Numulariola tinctor* (Berk.) Martin  
 syn. *Hypoxylon tinctor* Berkeley
- 37'. Ostioles papillate, vertices of perithecia evident; stromata orbicular to widely effuse; spores gibbous, narrow-ended,  $7-10 \times 23-33\mu$   
*Numulariola hemisphaerica* (Mill.) Martin  
 syn. *Hypoxylon hemisphaericum* Miller
38. (21) Stromata small, short cylindric, definitely circular or broad oval in outline; upper surface concave (or convex when perithecia elongate); perithecia ovate to elongate cylindric ..... 39
- 38'. Stromata more effuse, not restricted to any one shape or size, if sometimes circular or elliptic, then upper surface flat or convex and perithecia not elongate narrow. . . 43
39. Spores cylindric with rounded ends,  $3.0 \times 5.0\mu$ , perithecia tubular or elongate oval,  $600-800 \times 3,500-4,000\mu$ ; stromal surface convex  
*Numulariola cylindrophora* (E. & E.) Martin  
 syn. *Hypoxylon cylindrophorum* Ellis & Everhart
- 39'. Spores of different shape; perithecia broader; stromal surface concave ..... 40
40. Basal tissue well developed, exceeding  $\frac{1}{2}$  the height of the stroma ..... 41
- 40'. Basal tissue not conspicuous ..... 42
41. Ostioles umbilicate with raised rim; spores elliptic fusoid, dark brown,  $4.5 \times 10.5\mu$ ; hyaline spore sheath not prominent  
*Numulariola signata* (Morg.) Martin (Plate II: 11)  
 syn. *Nummularia signata* Morgan
- 41'. Ostioles umbilicate but at stroma level; spores subglobose,  $12.0 \times 14.5\mu$ , with conspicuous hyaline sheaths  
*Numulariola discreta* (Schw.) House (Plate II: 6, 8)  
 syn. *Nummularia discreta* (Schw.) Tulasne  
*Nummularia discinola* (Schw.) Cke.
42. (40) Ostioles umbilicate or not visible; spores elliptic,  $5 \times 10\mu$   
*Numulariola guaranitica* (Speg.) Martin  
 syn. *Nummularia guaranitica* Spegazzini
- 42'. Ostioles papillate or raised; spores elliptic, fusoid,  $5.0 \times 10.5-11.0\mu$   
*Numulariola kalchbrenneri* (Sacc.) Martin (Plate II: 7, 9)  
 syn. *Hypoxylon kalchbrenneri* Saccardo  
*Nummularia kalchbrenneri* (Sacc.) Miller
43. (38) Basal tissue well developed, exceeding  $\frac{1}{2}$  the height of the stroma ..... 44

- 43'. Basal tissue not conspicuous. ....47
- 44'. Interior of stroma with dull yellow pigment, spores broad-ended. ....45
- 44'. Interior of stroma without yellow pigment, spores narrow-ended. ....46
45. Stroma small, erumpent through bark and often linear; ectostroma not recognizable; spores equilateral elliptic to cylindric,  $3.5 \times 8.0\mu$   
*Numulariola linearis* Martin nov. sp.
- 45'. Stromata of moderate size, effuse; spores equilateral elliptic,  $7.0 \times 17.0\mu$   
*Numulariola morgani* (Mill.) Martin  
 syn. *Nummularia morgani* Miller
46. (44) Stroma effuse, at least 20 mm long; basal tissue mixed with wood and pale brown to white in colour; ectostroma pale grey tinted purple; spores gibbous,  $7.0 \times 14.5\mu$   
*Numulariola fuscella* (Mill.) Martin  
 syn. *Hypoxylon fuscellum* Miller
- 46'. Stroma aplanate to broad urceolate, up to 25 mm long, basal tissue discrete, dull white to pale brown; ectostroma dull brown; spores elliptic, fusoid,  $5.0-5.5 \times 12.0-12.5\mu$   
*Numulariola repanda* (Fr.) House-Fig. II: 10)  
 syn. *Nummularia repanda* (Fr.) Nitschke
47. (43) Ectostroma initially saffron, later white to pale cineraceous grey; ostioles umbilicate; spores equilateral to gibbous, broad-ended  $4.0-4.5 \times 8.5-9.5\mu$   
*Numulariola hypophlaea* (B. & Rav.) Martin  
 syn. *Hypoxylon hypophlaeum* (B. & Rav.) Miller  
*Nummularia hypophlaea* (B. & Rav.) Cooke
- 47'. Ectostroma initially white, later white to dull grey at maturity .....48
- 47'. Ectostroma initially olivaceous or brown, later dull brown or grey black; if feebly persistent then entostroma similar .....49
48. Spores equilateral, broad-ended  $4.5-5.5 \times 10.0-14.0\mu$   
*Numulariola cineraceo-lilacina* (Miller) Martin  
 syn. *Hypoxylon cineraceo-lilacinum* Miller
- 48'. Spores equilateral, broad or narrow-ended,  $12.0-13.5 \times 24.0-30.0\mu$   
*Numulariola atropunctata* (Schw. ex Fr.) House  
 syn. *Hypoxylon atropunctatum* (Schw. ex Fr.) Cooke  
*Nummularia atropunctata* (Schw. ex Fr.) v. Hohnel
49. (47) Ostioles umbilicate, uncarbonized and soft corky, appearing as yellow or pale dots against the darker plane stroma surface; spores equilateral, broad-ended,  $7.5 \times 15.5\mu$   
*Numulariola albosticta* (E. & M.) Martin  
 syn. *Hypoxylon albostictum* (E. & M.) Miller  
*Nummularia albosticta* Ellis & Morgan
- 49'. Ostioles variable but always rigid and black. ....50
50. Ostioles usually clearly papillate, surface always dull, ectostroma chestnut to dull brown; spores elliptic equilateral to navicular, broad or narrow-ended, chestnut to dark brown,  $7.0-9.0 \times 15.0-21.0\mu$   
*Numulariola mediterranea* (DN) Martin  
 syn. *Hypoxylon mediterraneum* (DN) Miller  
*Nummularia mediterranea* (DN) Saccardo
- 50'. Ostioles if clearly papillate, then surface smooth and shiny; ostioles normally indistinct papillate to umbilicate or not visible; ectostroma dull brown or olivaceous to black when persistent. ....51
51. Stroma surface shiny black; stromata usually robust with large perithecia,  $250-400 \times 800-900\mu$ ; spores equilateral broad-ended,  $6.0 \times 13.5\mu$   
*Numulariola nummularia* (Bull. ex Fr.) Martin  
 syn. *Hypoxylon nummularium* Bull. ex Fr.  
*Nummularia bulliardi* Tulasne
- 51'. Stroma surface glossy to matt, stromata variable in shape but usually less extensive and with smaller tightly packed perithecia. ....52
52. Spores amber to pale brown, subhyaline, elliptic to cylindric,  $2.0-3.0 \times 5.0-7.0\mu$  stromata restricted, often orbicular; ostioles sometimes annulate papillate  
*Numulariola microplaca* (B. & C.) Martin  
 syn. *Hypoxylon microplacum* (B. & C.) Miller
- 52'. Spores darker, stromata not necessarily orbicular. ....53

53. Spores equilateral, or gibbous and not exceeding  $8\mu$  long.....54  
 53'. Spores inequilateral and exceeding  $8\mu$  long.....61  
 54. Spores equilateral to gibbous, broad-ended,  $3.5 \times 5.5\mu$   
*Numulariola maculata* (Theiss.) Martin  
 syn. *Nummularia maculata* Theissen  
 54'. Spores equilateral, longer.....55  
 55. Spores with prominent gelatinous spore-sheaths, elliptic equilateral with broad or narrow ends,  $7.5 \times 13.0\mu$ ; stromata restricted, oval  
*Numulariola cineta* (Ferd. & Winge) Martin  
 syn. *Nummularia cineta* Ferdinandsen & Winge  
 55'. Spores without prominent gelatinous spore-sheaths, stromata greatly varying in size.....56  
 56. Spores fusoid with narrow ends.....57  
 56'. Spores broad-ended.....58  
 57. Spores  $5.5-6.5 \times 10.5-14.0\mu$ , with tapered ends; ubiquitous  
*Numulariola exutans* (Cke.) Martin  
 syn. *Nummularia exutans* Cooke  
 57'. Spores  $6.5-8.5 \times 14.5-15.0\mu$ , with abruptly narrow ends; Southern U.S.A. distribution  
*Numulariola rumpens* (Cke.) Martin  
 syn. *Nummularia rumpens* Cooke  
 57''. Spores  $7.0-7.5 \times 11.5-14.5\mu$ , broad elliptic with abruptly narrowed ends; warm temperate to subtropical distribution  
*Numulariola pseudopachyloma* (Speg.) Martin  
 58. Spores broad oval or elliptic, width usually exceeding half the length.....59  
 58'. Spores narrow elliptic, width usually not greatly exceeding half the length.....60  
 59. Spores  $7.0-7.5 \times 11.5-14.5\mu$   
*Numulariola pseudopachyloma* (Speg.) Martin  
 59'. Spores  $9.0-9.5 \times 12.0-12.5\mu$   
*Numulariola macula* (Schw.) Martin  
 syn. *Hypoxylon maculum* (Schw.) Miller  
 60. (58) Spores  $5.0-8.0 \times 10.5-15.5\mu$   
*Numulariola merrillii* (Bres.) Martin  
 syn. *Nummularia merrillii* Bresadola  
 60'. Spores  $9.0 \times 21.0\mu$   
*Numulariola bartholomaei* (Peck) Martin  
 syn. *Hypoxylon bartholomaei* (Peck) Miller  
 61. (53) Spores broad-ended, gibbous,  $25.0 \times 44.5\mu$   
*Numulariola diatrypeoides* (Rehm) Martin  
 syn. *Nummularia diatrypeoides* Rehm  
 61'. Spores narrow-ended.....62  
 62. Spores gibbous to navicular,  $6.2 \times 13.0\mu$   
*Nummularia theissenii* (Syd.) Martin  
 syn. *Numulariola theissenii* Sydow  
 62'. Spores gibbous,  $8-14 \times 14-24\mu$   
*Numulariola australis* (Cke.) Martin  
 syn. *Nummularia australis* Cooke  
 62''. Spores gibbous to navicular,  $8.0 \times 29.5-9.5 \times 27.0\mu$   
*Numulariola sinuosa* (Theiss.) Martin  
 syn. *Hypoxylon sinuosum* (Theiss.) Miller  
*Nummularia sinuosa* Theissen  
*Hypoxylon fragillimum* (Rehm) Miller  
*Nummularia fragillima* Rehm

## Analysis of Species

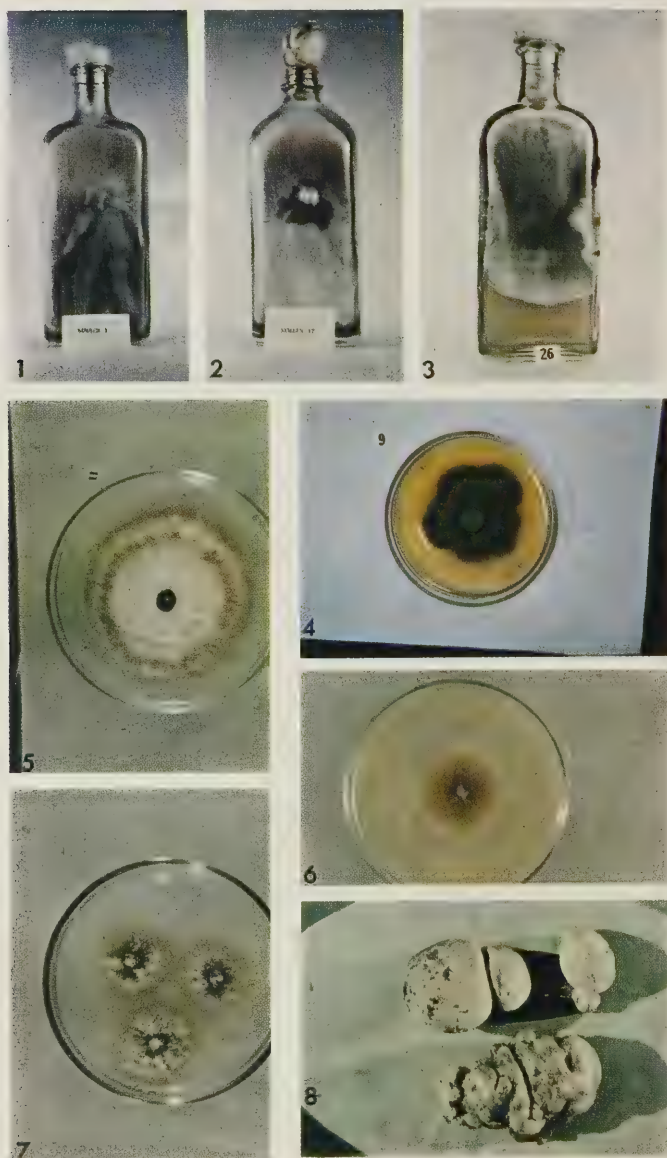
### 1. *Numulariola kalchbrenneri* (Sacc.) Martin nov. comb. (Plate II: 7, 9)

sub *Hypoxylon kalchbrenneri* Sacc.

Saccardo P. A. Syll. Fung. 1, 364, (1882)

sub *Nummularia kalchbrenneri* (Sacc.) Miller.

Miller J. H. Bothalia 4, 260, (1942).





Stromata orbicular or almost cylindrical, definitely restricted in extent and never widely effused, with smooth, often shiny, characteristically concave surface with raised margin;  $2.6-6.0 \times 3.2-8.0 \times 0.8-0.9$  mm. Ectostroma partly persistent, corky, black at maturity; entostroma carbonaceous to corky, dull brown to black. Perithecia immersed, large, flask shaped, generally flattened by mutual pressure,  $400-650 \times 750-850\mu$ ; ostioles at centre of stroma, conspicuously papillate and raised above the stromal level. Asci not seen. Spores oval elliptic, equilateral with bluntly pointed ends, medium brown,  $3.5-7.0 \times 8.0-13.0\mu$ , ave.  $5.0 \times 10.9\mu$ .

South African Hosts: The species shows a strong preference for *Gonioma kamassi* and is possibly host-specific. This feature and the somewhat thinner stroma doubtfully separates the species from the north temperate *N. discreta* (Miller, loc. cit.).

Material examined:—

Martin 35, 313, 402, 422, 571, 1188; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1959, 1962).

Cultural characters. (Plate V: 6):—

Colonies canescent felty, forming a thick closely appressed mat of aerial mycelium up to 1 mm high, much denser than in other members of this group except *N. nummularia*. At first the mycelium is dull white or nearly so, later it turns dull yellow, often tinted green. The surface of the colony is coarse granulate but smoother than in other species, without the characteristic straggling surface. Margin distinct as a submersed yellow zone 3 mm broad, with effuse hyphae. Conidia dull yellow but not conspicuous, normally produced at centre of the colony after 14 days. Stain diffuse orange to ochre-yellow, very conspicuous, developing after 7 days. Growth rate moderate, 2.8 mm/day at 25°C. Growth on other media broadly similar except on Czapek where initial development is submersed for a far longer period and the stain is less pronounced. On the whole the cultural characters of this species are intermediate between those of *Hypoxyton truncatum* and *N. nummularia*.

Microscopic characters:—

Primary mycelium undiagnostic, marginal hyphae up to  $3.8\mu$  in diameter. Secondary mycelium rather slight in quantity, comprising long sparingly branched hyphae  $3.6-5.2\mu$  in diameter.

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PLATE V. Cultural characters. All cultures on malt at 25°C and 2 weeks old unless stated. 1, 2. *Numulariola merrillii*; bottle cultures. Note central olivaceous conidiophores at right. 3. *Numulariola nummularia*; bottle culture. 4. *Numulariola nummularia*; plate culture. 5. *Numulariola mediterranea*; plate culture. 6. *Numulariola kalchbrenneri*; young culture 1 week old showing smooth instead of coarse surface. 7. *Daldinia eschscholzii*; young culture 1 week old on Czapek, showing characteristic spreading cottony growth. 8. *Daldinia concentrica*; stromata ( $\times 0.3$ ).



Conidiophores and conidia (Fig. I: 3):—

The conidiophores are not well-differentiated except by the extremely close branching, and the basal swelling beneath each vertical of fertile branches. They are smooth-walled and colourless, variable in length,  $90-150 \times 2.6-4.0\mu$ , dichotomously or ternately branched to the first or second degree distally; secondary branches in close clusters of that they are often difficult to distinguish apart. Fertile branches unmodified or swollen, clavate or more commonly elliptic, lying free or in trident formation,  $6-40 \times 2.5-5.0\mu$ . The conidia are produced in dense clusters, pleuracrogenous, broad oval to narrow clavate, yellow, tinted green en masse,  $1.7-3.1 \times 4.0-8.0\mu$ , ave.  $2.5 \times 5.6\mu$ .

2. *Numulariola polysperma* (Mont.) Martin nov. comb. (Plate II: 12; Plate IV: 8, 12, 15)

sub *Camarops polyspermum* (Mont.) Miller

Dennis R. W. G. British Cup Fungi 179, (1960). Miller J. H. Trans Brit. Mycol. Soc. 15, 151, (1930); World Species of *Hypoxylon* 140, (1961)

sub *Hypoxylon atroviride* E. & E. Ellis J. B. & B. M. Everhart Proc. acad. nat. Sci. Philad. III, 24, 346, (1894).

sub *Hypoxylon polyspermum* Montagne

Berkeley M. T. Jour. Linn. Soc. 10, 385, (1869). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 69, (1888). N. Amer. Pyren. 642, (1892). Montagne J. F. C. in Sagra: Hist. de l'île de Cuba 345, (1838—1842); Ann. Sci. Nat. II, 17, 124, (1842); Syll. Crypt. 215, (1856). Theissen F. Ann. Mycol. 6, 536, (1908)

sub *Numularia ustulinoidea* Hennings P. Hedwigia 36, 227, (1897)

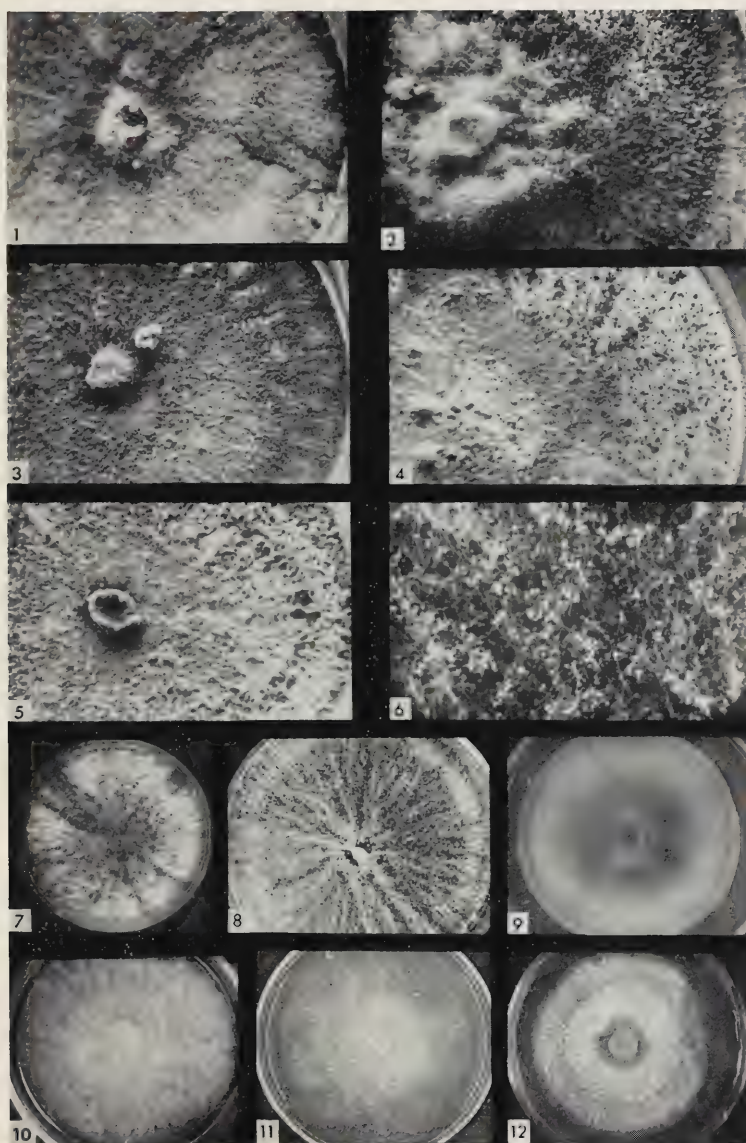
sub *Solenoplea microspora* Starbäck. Lloyd C. G. Myc. Writ. 7, 1313, (1924).

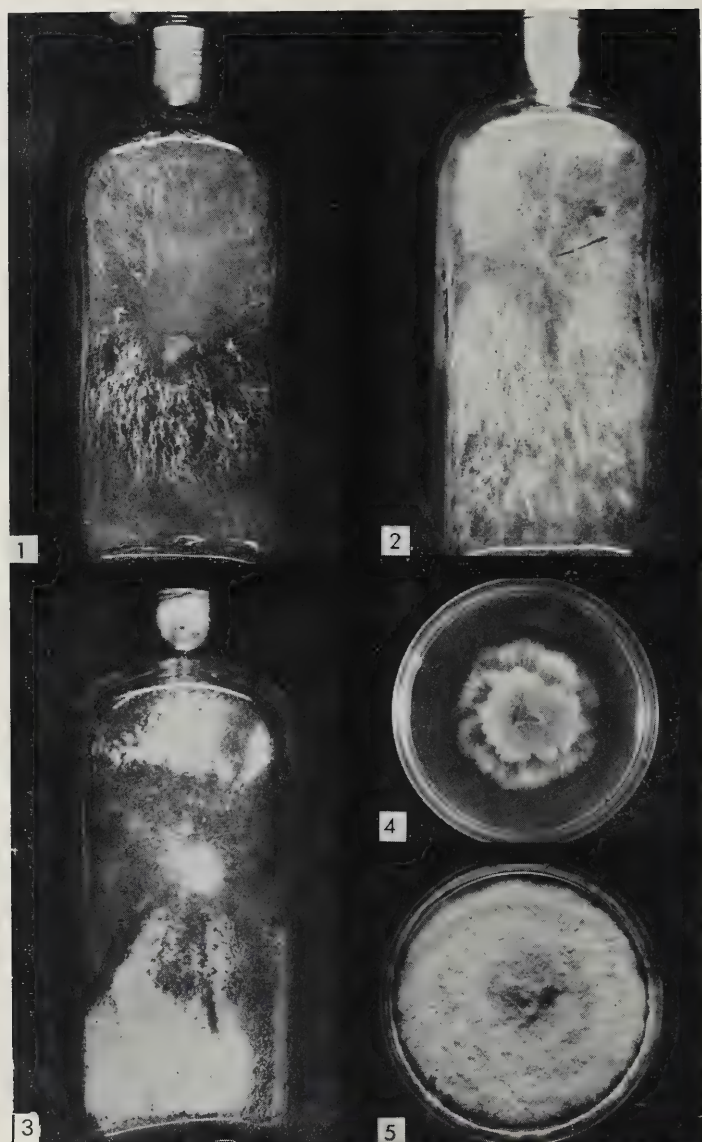
Starbäck K. Brit. Svensk. Vet. akad. Handl. 27, IX, 13, (1901). Theissen Ann. Mycol. 7, 158, (1909).

Stromata erumpent, deeply embedded between bark and wood and usually partly covered by host material at maturity, elliptic or cylindric to somewhat turbinate, with flat to undulating or concave surface,  $6.0-24 \times 11-44 \times 3.0-8.0$  mm. Ectostroma dull brown, usually at least partially persistent, smooth; entostroma black and carbonaceous above the perithecia, variably developed at the base, corky, dull brown to black. Perithecia immersed, elliptic to cylindric,  $500-1300 \times 2900-4000\mu$ , close crowded in palisade formation and sometimes coalescing; ostioles medium papillate, umbilicate, or merely raised and not distinctly either type. Asci cylindric to clavate, with monostichous or distichous arrangement of spores,  $50-65 \times 4-5\mu$ ; stipes  $22-30\mu$ .

PLATE VI. Cultural characters, continued. All colonies on malt at  $25^{\circ}\text{C}$  and at 2 weeks, unless otherwise stated.

1, 2. *Daldinia concentrica*; great variation in mycelial aggregates and flecks of stain in medium. 3. *Daldinia bakeri*; mycelial aggregate, of small size. 4. *Daldinia vernicosa*; prominent mycelial aggregates. 5. *Daldinia eschscholzii*; mycelial aggregates concealed by coarse growth. 6. *Daldinia occidentale*; close-up of colony surface showing prominent conidiophores. 7. *Daldinia eschscholzii*; typical *Daldinia* colony, with loose, rapidly spreading growth. On Leonian's agar. 8. *Numulariola mediterranea*. 9. *Numulariola pseudopachyloma*. 10. *Numulariola exutans*. 11. *Numulariola uni-apiculata*. 12. *Numulariola microplaca*.





Spores obconic, distal ends cylindric or elliptic and proximal ends narrowed, pale to medium brown,  $2.5-5.5 \times 5.0-8.5\mu$ , ave.  $3.7 \times 6.5\mu$ .

South African hosts: wood unidentified.

Material examined:—

- Martin 1836; Blyde River Canyon, E. Transvaal, South Africa, (1968).
- sub *Camarops polyspermum* Miller 1817; on *Acer negundo*, Athens, Ga., U.S.A., (1926), (Mill.)
- sub *Hypoxylon atroviride* Nuttall; West Virginia, U.S.A., (1894), (NYBG).

Cultural characters (Plate VIII: 4, 5):—

Colonies velvet felty, coarse but not straggling as in other species, with vertical tufts of mycelium produced by 7 days, zonate with one or two broad irregular zones suggestive of *Hypoxylon albocinctum*, mainly pure white. Margin distinct, submerged, segmented to entire; hyphae lying together. Conidia not apparently developed. Stain uniform to mottled, light ochraceous to warm sepia, deepening to ochre brown with age. Growth rate moderate, 3.2 mm/day at 25°C.

Microscopic characters (Plate IX: 1):—

Primary mycelium undiagnostic, maximum diameter of marginal hyphae =  $2.0\mu$ . Secondary mycelium barely distinct, loosely organized, amber,  $3.4-5.9\mu$  in diameter.

Conidiophores and conidia:—Sterile.

### 3. *Numulariola microplaca* (Berk. & Curt.) Martin nov. comb. (Plate III: 1)

- sub *Anthostoma microplacum* (Berk. & Curt.) Sacc.
- Saccardo P. A. Sylloge Fungorum **1**, 298, (1882).
- sub *Diatrype microplaca* Berk. & Curt.
- Berkeley M. J. Jour. Linn. Soc. **10**, 386, (1869)
- sub *Hypoxylon microplacum* (Berk. & Curt.) Mill.
- Miller J. H. Mycologia **33**, 77, (1941); World Species of *Hypoxylon* 129, (1961).
- sub *Nummularia gracilentia* Sydow. Sydow H. & P. Ann. Mycol. **8**, 37, (1910)
- sub *Nummularia lamprostoma* Sydow. Sydow H. Ann. Mycol. **18**, 99, (1920)
- sub *Nummularia microplaca* (Berk. & Curt.) Cke.
- Cooke M. C. Grevillea **12**, 8, (1883); Handbook of Australian Fungi 291, (1892).
- Ellis J. B. & B. M. Everhart Jour. Mycol. **5**, 21, (1890); N. Amer. Pyren. 624, (1892).
- O'Neal C. E. Proc. Indiana Acad. Sci. **1914**, 239, (1914). Saccardo P. A. Syll. Fung. **1**, 298, (1882); Atti R. Instituto Ven. Sci. lett. & art. **3**, 3, (1885).
- ? sub *Nummularia mölleriana* Henn.
- Hennings P. Hedwigia **36**, 228, (1897); Ibid. **41**, 14, (1902).
- sub *Nummularia scutata* Henn.
- Cooke M. C. Grevillea **12**, 7, (1883). Hennings P. Bot. Jahrb. **14**, 365, (1892). Rehm N. Philipp. Jour. Sci. **8** C, 400, (1913); Leaf. Philipp. Bot. **8**, 2961, (1916).

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PLATE VII. Cultural characters, continued.

1—3. The straggling growth type in *Numulariola*. 1. *Numulariola microplaca*; on maize agar. 2. *Numulariola exultans*. 3. *Numulariola uni-apiculata*. 4, 5. *Numulariola polysperma*;  $7 \times 14$ —day old colonies, coarse but not straggling. Vertical tufts were present but are not apparent here.



Stromata aplanate, usually restricted and orbicular rather than indefinitely effused, convex to flat,  $1.5-4.2 \times 3.6-11 \times 0.4-0.7$  mm. Ectostroma feebly persistent, dull brown. Entostroma somewhat verrucose, dull black, sometimes glossy, with corky dark brown interior. Perithecia immersed, close crowded, broadly oval to somewhat angular,  $200-500 \times 300-600\mu$ ; ostioles medium papillate, indistinct or umbilicate, sometimes surrounded by annular discs representing the sloughing off of the ectostroma as in the Annulata group of *Hypoxylon*. Asci cylindric,  $42-100 \times 3-4\mu$ ; stipes  $9-54\mu$ . Spores cylindric or oval, gibbous or navicular, amber to pale brown or pale brownish grey, subhyaline,  $1.5-4.0 \times 4.5-9.0\mu$ , ave.  $2.5 \times 5.8\mu$ .

South African Hosts: Unidentified.

Material examined:—

Hesler 10230; Norris, Tenn., U.S.A., (1937), (Mill.). Martin 116, 117, 127, 322, 426, 527; Nature's Valley, Knysna District, Western Cape, South Africa (1958, 1959). Martin 1771 ex Carroll 173; Costa Rica, (1962).

Cultural characters (Plate VI: 12; Plate VII: 1):—

Colonies initially canescent, later coarse but only appearing straggling in bottle culture, with mycelium 2—3 mm high, dull white, subhyaline to opaque; mycelial aggregates present in moderate quantity. Margin not distinct, submersed to canescent, effuse but without the long exploratory hyphae characteristic of other species. Conidia produced with age on small floccose tufts of aerial mycelium, greenish grey. Stain light brown deepening to murky. Growth rate rapid, 4.1 mm/day at 25°C. Growth on other media similar though with distinct margins, except on Czapek where mycelium is almost completely submersed with sodden or gelatinous aspect.

Microscopic characters:—

Primary mycelium stout; marginal hyphae up to  $4.0\mu$  in diameter. Secondary mycelium loosely organized,  $2.3-6.3\mu$  in diameter.

Conidiophores and conidia (Fig. I: 4):—

The conidiophores are normally distinct from the vegetative mycelium by their compact type of branching although they are not tinted, nor do they have warted walls. In form they represent a type of *Acrostaphylus* intermediate with *Sporothrix*;  $440-550 \times 2.9-3.5\mu$ , branched dichotomously to the second

FIG. I. Microscopic Characters.

1—2. Marginal hyphae. 1. *Daldinia concentrica*. 2. *Numulariola mediterranea*. 3—7. Conidiophores and conidia. 3. *Numulariola kalchbrenneri*. 4. *Numulariola microplaca*. 5. *Numulariola uni-apiculata*. 6. *Numulariola nummularia*. 7. *Daldinia eschscholtzii*. 8—10. Secondary mycelium. 8. *Numulariola merrillii*. 9. *Numulariola exutans*; young hypha at right, beaded older mycelium on the left. 10. *Numulariola mediterranea*. 11. Chlamydo-spores of *Numulariola pseudopachyloma*.





degree. Fertile branches not markedly swollen but with conspicuously bloated or grotesquely shaped apices;  $10-30 \times 1.7-3.2\mu$ . Conidia acrogenous, on slender sterigmata, narrow pyriform to elongate elliptic, normally inequilateral with acute or acuminate bases, light olive green en masse,  $1.1-2.3 \times 4.3-7.7\mu$ , ave.  $1.6 \times 6.3\mu$ .

#### 4. *Numulariola nummularia* (Bull. ex Fr.) House (Plate III: 4)

- House W. D. N.Y. State Museum Bull. **266**, 49, (1925).  
 sub *Biscogniauxia bulliardi* (Tul.) Kuntze O. Rev. Gen. Pl. 2, 398, (1891).  
 sub *Hypoxylon ellipticum* Cooke M. C. Handbook of Australian Fungi 296, (1892).  
 sub *Hypoxylon nummularium* Bull. ex Fr.  
 Berkeley M. J. in Smith: English Flora **5**, (2) 240, (1836); Grevillea **4**, 94, (1876). Bresadola G. & P. A. Saccardo Malpighia **11**, 294, (1897). Bulliard P. Hist. Champ. de Fr. 179, (1791). Currey F. Trans. Linn. Soc. Lond. **22**, 268, (1859). Dennis R. W. G. British Cup Fungi 178, (1960). Fries E. M. Syst. Mycol. 348, (1823). Fuckel L. Symb. Myc. 236, (1869-1870). Jacewski A. L. Bull. Soc. Myc. de France **11**, 110, (1895). Lambotte E. Flora Myc. Belge 426, (1880). Lindau G. in Engler & Prantl: Die Natürlichen Pflanzenfamilien I, 483 (1897); Die Mikroskopischen Pilze in Krypt. für Anfänger **2**, (1), 134, (1897). Miller J. H. Jour. Dept. Agric. Puerto Rico **14**, 274, (1930); Trans. Brit. Mycol. Soc. **17**, 128, (1932); World Species of *Hypoxylon* 121, (1961). Quélet L. Champ. Jura & Vosges III, 492, (1875). Rabenhorst G. L. Deutschl. Kryptflor. I, 217, (1844). Rabenhorst L. Kryptflor. Deutsch. II, 847, (1887). Sydow H. & F. Petrak Ann. Mycol. **20**, 186, (1922).  
 sub *Nummularia anthracina* (Schmidt) Trav.  
 Rehm H. Ann. Mycol. **6**, 121, (1908); Leaf. Philipp Bot. **6**, 1943, (1913). Traverso J. B. Flor. Crypt. Pyren. **1**, 57, (1906).  
 sub *Nummularia bulliardi* Tul.  
 Cooke M. C. Handbook of British Fungi II, 798, (1871); Handbook of Australian Fungi 291, (1892). Ellis J. B. & B. M. Everhart Jour. Mycol. **5**, 20, (1890); N. Amer. Pyren. 624, (1892). Hennings P. Bot. Jahrb. **22**, 78, (1895); Hedwigia **42**, (81), (1903); Ibid. 43, 206 (1904). Kickx J. Flore crypt. Flanders 308, (1867). Lloyd C. G. Myc. Writ. **7**, 1311, (1924); Ibid. 7, 1353 (1925). Nitschke T. Pyr. Germ. **1**, 60, (1867). O'Neal C. E. Proc. Indiana Acad. Sci. 1914, 239, (1914). Rehm H. Ascomycetes Lokjani lecti in Hungaria, 33, (1882); Hedwigia **28**, 353, (1889). Rick J. Brotéria ser. bot. **25**, 45, (1931). Shear C. L. Mycologia **33**, 318, (1941). Tulasne L. & C. Selecta Fungi Carpologia **2**, 43, (1863).  
 sub *Nummularia nummularia* (Bull.) Schrot.  
 Schroter J. in Cohn: Kryptflor. Schlesien 458, (1908).  
 sub *Sphaeria anthrocina* Schmidt  
 Kunze G. & J. K. Schmidt Mykologische Hefte I, 55, (1819).  
 sub *Sphaeria bullata* Hoffman G. E. Vegetabilia cryptogamica 1, 5, (1787).  
 Hooker W. J. Flora Scotia II, 5, (1821).  
 sub *Sphaeria nummularia* De Candolle  
 Berkeley M. J. Ann. & Mag. Nat. Hist. **3**, 398, (1839) De Candolle A. Flor. Fr. **2**, 290, (1805).

Stromata aplanate, erumpent, but robust, effuse,  $19-30 \times 60-80 \times 0.9-1.0$  mm, with convex surface. Ectostroma not persistent; entostroma shiny metallic black, mostly carbonaceous, concolorous. Perithecia immersed, close crowded, long ovate,  $250-400 \times 800-900\mu$ , often several to one ostiole; ostioles papillate and rather easy to distinguish in comparison with those of other species. Asci cylindric,  $95-125 \times 6-7\mu$ ; stipes  $20-45\mu$ . Spores oval, equilateral, dark brown,  $4.5-7.5 \times 9.0-17.5\mu$ , ave.  $6.1 \times 13.5\mu$ .

South African Hosts: Unidentifiable.

Material examined:—

Martin 275; Alexandria forest, Eastern Cape, South Africa (1958).

Cultural characters (Plate V: 3, 4; Plate VII: 2):—

Colonies felty, with very dense aerial mycelium, eventually 1–3 mm high, white at first (10 days), tinted pale yellow at the site of inoculation, later tinted pale purple throughout. Surface initially coarse but not as markedly so as in other spp, later becoming smooth; mycelial aggregates absent. Margin not distinct, entire with effuse widely separated hyphae. Conidia pale purple, produced after 10–14 days, not conspicuous. Stain at first delicate pink, deepening to purple brown. Growth rate moderate, 3.3 mm/day at 25°C.

Microscopic characters:—

Primary mycelium unusually stout, exploratory hyphae with short and relatively narrow branches; maximum diameter of marginal hyphae =  $5.5\mu$ . Secondary mycelium uniform, loosely organized,  $1.7$ – $4.5\mu$  diam.

Conidiophores and conidia (Fig. I: 6):—

These are of the usual *Acrostaphylus* type, clearly distinct due to determinate growth, purple tint and warted walls,  $90$ – $140 \times 3.6$ – $5.9\mu$ ; primary axes branched at the apices with 2–4 branches at each node. Fertile branches usually in close verticils, very short and stout,  $6$ – $16 \times 3$ – $5\mu$ , unseptate, with broad clavate apices. Conidia acrogenous, sessile, pyriform to narrow clavate, purple brown en masse,  $1.4$ – $2.6 \times 4.3$ – $7.6\mu$ , ave.  $1.9 \times 5.8\mu$ .

### 5. *Numulariola merrillii* (Bres.) Martin nov. comb. (Plate III: 8; Plate IV: 4, 5)

sub *Hypoxyton nummularium* var *merrillii* (Bres.) Miller

Miller J. H. World Species of *Hypoxyton* 126, (1961)

sub *Nummularia merrillii* Bresadola G. Hedwigia 56, 307, (1915)

Stromata orbicular, linear elliptic or indefinitely effused, aplanate, erumpent through bark at maturity or occasionally superficial on decorticated wood,  $3.0$ – $16 \times 3.6$ – $62 \times 0.6$ – $1.0$  mm. Surface of stroma concave, flat or convex. Ectostroma and initial stage olive green, ectostroma shed at maturity or becoming partially fused with the entostroma. Ectostroma black, smooth, glossy but not markedly shiny, often with a matt surface, mostly carbonaceous. Perithecia immersed, oval or constricted by mutual pressure, usually close packed,  $100$ – $500 \times 600$ – $800\mu$ ; ostioles papillate or indistinct. Asci cylindric, short stipitate,  $75$ – $110 \times 6$ – $8\mu$ ; stipes  $7$ – $25\mu$ . Spores oval to elliptic, equilateral, dark brown,  $4.5$ – $9.0 \times 8.0$ – $17.5\mu$ , ave.  $6.5 \times 13.4\mu$ .

South African Hosts: Probably a wide range, known to comprise:—

*Maytenus buxifolia*, *Olea capensis*, *Royena lucida*, *Trichocladus crinitus*, *Virgilina oroboides*.

## Material examined:—

A large quantity of material in the herbaria cited (Martin, 1968). Martin, 18, 23, 39, 61, 70, 300, 321, 423—5, 441—3, 445—7, 449, 480, 1045; Nature's Valley, Knysna District, Western Cape, South Africa, (1958, 1958, 1962). Martin 226; Hogsback, nr Alice, Eastern Cape, South Africa (1958). Martin 263; Kariaga River, Eastern Cape, South Africa (1958). Martin 590; Descanso Gardens, Los Angeles, California, U.S.A., (1961). Martin 762, 764, 765, 767, 768, 785—7; O'Brien, Northern California, U.S.A., (1961). Martin 791, 800, 815, 824, 826—8, 838—840, 852, 854, 875; Arcata, N. Calif., U.S.A., (1961). Martin 931; Mazatlán, Sinaloa, Mexico, (1961). Martin 1059; Santa Paula Mtn., California, U.S.A., (1961). Martin 1553; San Blás, Nayarit, Mexico, (1962).

## Cultural characters (Plate V: 1, 2):—

Colonies at first canescent appressed, then rapidly developing a characteristic loose cottony to felty, dull white, subhyaline to opaque mat about 3 mm high, with coarse straggling hyphae. After 5 days the mycelium becomes tinted with various colours, usually buff or dark brown and rose; olive green near the site of inoculation. Old cultures become overlaid with pleomorphic velvet white mycelium. Mycelial aggregates are absent. Margin not distinct, entire with widely effused submersed hyphae 3—10 mm long. Conidia variable in colour but not conspicuous, appearing by 7—10 days. Stain in varying shades of yellow ochre, yellow pink, and also olive green. Growth rate rapid, 7·1—7·7 mm/day at 25°C.

## Microscopic characters (Fig. I: 8):—

Primary mycelium relatively stout as in *N. nummularia*, up to  $4\cdot4\mu$  in diameter. Secondary mycelium reticulate, continuous but not as conspicuous as in *N. exutans*,  $2\cdot5$ — $6\cdot4\mu$  diam.

## Conidiophores and conidia (See Martin (1967), p. 230, fig. 3):—

These are usually sharply distinct by determinate growth, dark colouration, and warted walls, but there is some variation in form from simple types approaching *Sporothrix* to the typical complex multibranching ones with pre-dominantly distal branching that belong to *Acrostaphylus*;  $200$ — $750 \times 4\cdot3$ — $6\cdot3\mu$ . Usually there is a long stout axis tinted amber or dark brown, terminating in a "head" of closely set fertile branches, 2—4 of these arising at a node. The fertile branches are swollen, clavate or elliptic, and are fairly short, lying free or in trident formation,  $6\cdot0$ — $17 \times 3\cdot0$ — $4\cdot3\mu$ . Conidia are borne in apical clusters, usually sessile, sometimes borne on slender sterigmata, elliptic to clavate with narrow bases, white en masse,  $1\cdot7$ — $2\cdot6 \times 3\cdot7$ — $7\cdot2\mu$ , ave.  $2\cdot3$ — $4\cdot7\mu$ .

6. *Numulariola exutans* (Cke.) Martin nov. comb. (Plate III: 3)

sub *Anthostoma exutans* Cooke

Saccardo P. A. Syll. Fung. 1, 296, (1882)

sub *Diatrype exutans* Cooke

Cooke M. C. Jour. Linn. Soc. Lond. 17, 143, (1878).

sub *Hypoxylon exutans* Cooke

Cooke M. C. Grevillea 8, 66, (1879). Miller J. H. Bothalia 4, 255, (1942).

- sub *Hypoxylon nummularium* var *exutans* (Cke.) Miller  
Miller J. H. World Species of *Hypoxylon* 124, (1961).  
sub *Numularia exutans* Cooke.  
Cooke M. C. *Grevillea* 12, 8, (1883).

Stromata very similar to that in the preceding species, from which it is doubtfully separated; restricted and regular, oval in outline, or indefinitely effused and irregular,  $1.3-9.0 \times 2.0-48 \times 0.5-1.5$  mm; erumpent through bark. Surface of stroma usually convex, rarely flat. Ectostroma evanescent or partially retained (in which case ostioles are invisible), olive green to black. Entostroma carbonaceous, black, glossy to dull matt. Perithecia immersed, close crowded usually angular and constricted by mutual pressure, 130-500  $\times$  450-900 $\mu$ ; ostioles indistinct to papillate. Asci cylindric, short stipitate to nearly sessile, 75-115  $\times$  7-9 $\mu$ ; stipes 7-30 $\mu$ . Spores oval-elliptic, equilateral ends, rather narrow and somewhat fusoid, rarely gibbous, ends often narrow rounded, medium to dark brown, 4.5-9.0  $\times$  10.0-16.5 $\mu$ , ave. 6.3  $\times$  12.6 $\mu$ . South African Hosts: Unidentifiable.

Material examined:—

Martin 382, Rabbit's Wood, Grahamstown, E. Cape, South Africa (1958). Martin 612, 613, 616, 617; Sepulveda Canyon, Los Angeles, California, (1961). Shear; Palmetto, Oviedo, Florida, U.S.A., (1941), (Mill.)

Cultural characters (Plate VI: 10):—

Colonies densely felty to cottony, with coarse straggly surface; aerial mycelium up to 2 mm high, white subhyaline at first, becoming opaque and tinted faint olive green or ochre brown with age. Mycelial aggregates absent. Margin not distinct, canescent, with the usual submersed exploratory hyphae. Conidia inconspicuous, appearing by 7-10 days. Stain at first light ochre brown, deepening to feuille morte or olive green. Growth rate rapid, 6.3-6.9 mm/day at 25°C.

Microscopic characters (Fig. 1: 9):—

Primary mycelium broad; marginal hyphae up to 5.3 $\mu$  diameter. Secondary mycelium loosely organized, characteristically irregular vesiculate or beaded, 3.0-7.5 $\mu$  diam. Individual cells possibly behave as chlamydospores.

Conidiophores and conidia (Plate IX: 4):—

These parallel *N. merrilli* in range of form, branching varying from lax to extremely compact. They are tinted amber brown or olivaceous, 125-850  $\times$  2.4-6.0 $\mu$ , branched to the second degree or indefinitely with up to 5 branches per node. Fertile branches rarely narrow, usually swollen, clavate or elliptic, lying freely or in trident formation, 6.0-27  $\times$  1.2-4.3 $\mu$ . Conidia acrogenous, sessile or on slender sterigmata, subglobose to clavate, with narrow bases, white or ochraceous en masse, 1.2-3.7  $\times$  3.1-6.2 $\mu$ , ave. 2.5  $\times$  4.5 $\mu$ .



7. *Numulariola pseudopachyloma* (Speg.) Martin nov. comb.

- sub *Hypoxylon nummularium* var *pseudopachyloma* (Speg.) Miller  
 Miller J. H. World Species of *Hypoxylon* 125, (1961)  
 sub *Hypoxylon pseudopachyloma* Speg.  
 Spegazzini C. Bol. Acad. Nac. Cienc. Cordoba **11**, 203, (1887)  
 sub *Nummularia alabatenensis* Yates  
 Yates H. S. Phillip. J. Sci. **12**, 378, (1917)  
 sub *Nummularia asarcodes* Theiss.  
 Theissen F. Ann. Mycol. **6**, 349, (1908)  
 sub *Nummularia mauritanica* Berk. & Cke.  
 Cooke M. C. Grevillea **12**, 6. (1883)  
 sub *Nummularia plana* Petch  
 Petch T. Ann. Roy. bot. gard. Perad **8**, 166, (1924).

Stromata orbicular, restricted or somewhat effuse but not as extensive as *N. merrillii* and associated species;  $2.0-23 \times 4.5-48 \times 0.4-1.0$  mm. Surface of stroma flat or convex, dull brown to black, with a smooth matt surface. Ectostroma not persistent at maturity; entostroma black, carbonaceous, rather thin. Perithecia immersed, close crowded,  $200-500 \times 300-1000\mu$ ; ostioles conic papillate as in *N. mediterranea*, or indistinct. Asci cylindric, short stipitate,  $90-120 \times 6-10\mu$ ; stipes  $15-35\mu$ . Spores broadly oval elliptic, dark brown to black,  $5.0-10.5 \times 9.0-18.0\mu$ , ave.  $7.0 \times 13.1\mu$ .

South African Hosts: Unidentifiable.

Material examined:—

Martin 262; Kariëga River, Eastern Cape, South Africa, (1958). Rick 312; Sao Leopoldo, Brazil, (1906), (Mill.). Shear 26, 30, 39, 278; Hawaii, (1927—1928), (Mill.). Shear; on *Magnolia*, Oviedo, Fla., U.S.A., (1940), (Mill.).

Cultural characters (Plate VI: 9):—

Colonies canescent, appressed with sparse aerial mycelium; surface smooth or slightly cottony, dirty white behind the margin to grey at the centre, uniform or occasionally zonate. Margin not distinct, submersed, dull white subhyaline, entire, with compact to slightly effuse hyphae. Stain olive green to grey, eventually turning grey-black with age; produced after 10 days or variable in appearance. Growth rate slow, 1.9 mm/day at 25°C. Growth on other media similar except for Czapek on which it differs by greater luxuriance, forming a coarse felty mat 0.5 mm high, dull white in colour; stain grey-brown.

Microscopic characters (Fig. I: 11):—

Primary mycelium undiagnostic, rather narrow for this species group; marginal hyphae up to 3.0 mm in diameter. Secondary mycelium absent. Chlamydospores are often found on the submersed mycelium 1 week after inoculation. These are oval or pyriform with a thick refractive wall, dark amber or dark brown to black,  $5.1-5.7 \times 6.0-8.8\mu$ .

Conidiophores and conidia. Sterile.

This species is entirely different from the majority in this group in the peculiar characters of the mycelium in culture.

**8. *Numulariola uni-apiculata* (Penzig & Saccardo) Martin (Plate III: 2, 7)**

- sub *Hypoxylon uni-apiculatum* (Penz. & Sacc.) Miller  
Miller J. H. *World Species of Hypoxylon*, 111, (1961).
- sub *Nummularia papyracea* Rehm  
Rehm H. *Leafh. Philipp. Bot.* 6, 2208, (1914)
- sub *Nummularia uni-apiculata* Penz. & Sacc.  
Penzig O. & P. A. Saccardo *Malpighia* 11, 494, (1897).

Stromata aplanate, usually widely effused but sometimes restricted in extent,  $2.8-32 \times 3.5-80 \times 0.3-3.6$  mm; with smooth, rarely wrinkled matt surface when young, sometimes becoming glossy at maturity. The species is distinguished by its usually narrow breadth, punctate or indistinct ostioles and the dull brown to greenish grey hue of the persistent ectostroma. Entostroma brown, corky rather than carbonaceous between the perithecial. Perithecia relatively small, oval, closely packed,  $150-900 \times 180-2000\mu$ ; ostioles umbilicate. Asci cylindric,  $95-145 \times 7-8\mu$ ; stipes  $17-33\mu$ . Spores broadly oval, equilateral, gibbous or navicular, dark brown to nearly black, with broad obtuse proximal appendages,  $4.5-9.0 \times 8.5-14.5\mu$ , ave.  $6.1 \times 11.4\mu$ .

South African hosts: *Kiggelaria africana*.

Material examined:—

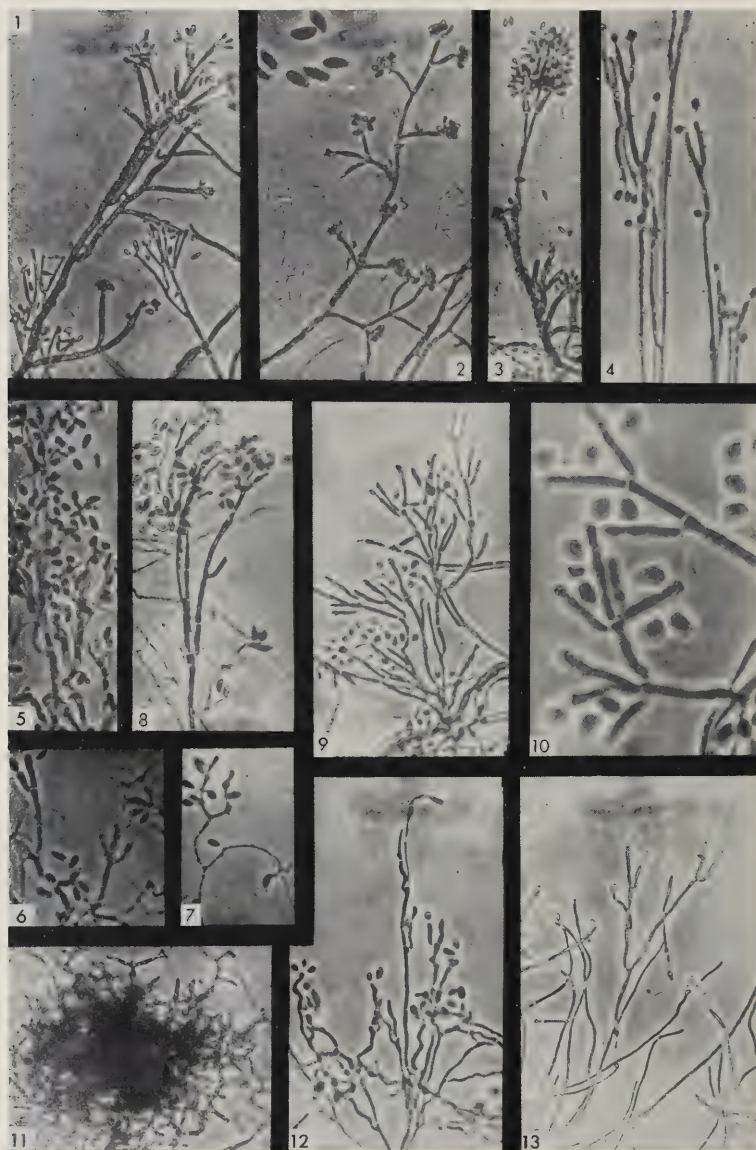
Deighton in IMI 58582; on *Hymenocardia lyrata*, Njala; Sierra Leone, (1954), (CMI). Martin 372; Nature's Valley, Knysna District, Western Cape, South Africa, (1958). Rehm; Mt. Maquilung, Los Banos, Laguna, Philippines, (1913), (Mill.). Shear & Stevens 23; Mauna Loa, Hawaii, (1928), (Mill.).

Cultural characters (Plate VI: 11; Plate VII: 3):—

Colonies at first loosely felty, becoming dense with age, forming a mat up to 2 mm high of white subhyaline aerial mycelium with the normal coarse straggling surface. General features are similar to those of *N. microplaca* but the mycelium is pure white without discolouration by conidia; margin not distinct, canescent to submersed, entire, effuse, with long pioneer hyphae extending up to 5 mm. Stain light buff to ochre brown appearing after 2 weeks and deepening slightly with age. Growth rate rapid, 5.1 mm/day at 25°C.

Microscopic characters:—

Primary mycelium broad, marginal hyphae up to  $7.7\mu$  diameter; side branches of similar diameter and length. Secondary mycelium characteristic, loose, light brown to colourless, hyaline, comprising long branched hyphae  $2.7-5.1\mu$  in diameter.



Conidiophores and conidia (Fig. I: 5):—

These are similar to those of *N. nummularia* and *N. merrillii*, variable in length but usually long,  $100\text{--}300 \times 3\cdot0\text{--}4\cdot0\mu$ , distinct from vegetative mycelium due to slightly darker colouration and fine wall pitting, branched to the second degree. Fertile branches arising 2—4 at a node, in single or compound verticils, swollen clavate but not as conspicuously stout as in allied species,  $9\cdot0\text{--}22 \times 2\cdot5\text{--}3\cdot5\mu$ . Conidia acrogenous, sessile, narrow clavate with blunt or rounded ends, white en masse,  $2\cdot3\text{--}3\cdot4 \times 3\cdot4\text{--}5\cdot7\mu$ , ave.  $2\cdot8 \times 4\cdot8\mu$ .

9. *Numulariola pithodes* (Berk. & Br.) Martin (Plate IV: 9)

Saccardo P. A. *Sylloge Fungorum* 1, 298, (1882)

sub *Diatrype pithodes* Berk. & Broome

Berkeley M. J. & C. E. Broome Jour. Linn. Soc. 14, 124, (1875)

sub *Hypoxylon pithodes* (Berk. & Br.) Miller

Miller J. H. World Species of *Hypoxylon* 113, (1961)

sub *Nummularia pithodes* (Berk. & Br.) Petch

Petch T. Ann. Roy. bot. gard. Perad. 4, 436—437, (1910)

sub *Nummularia fusco-disca* Pat.

Patouillard N. Bull. Soc. Myc. de Fr. 31, 35, (1915).

Stromata aplanate, flat, widely effused,  $12\text{--}42 \times 24\text{--}95 \times 1\cdot8\text{--}4\cdot4$  mm; ectostroma retained as a smooth matt external dull brown to black layer. Entostroma carbonaceous, usually rather well developed, dull brown to black, Perithecia immersed, close crowded, long ovate,  $300\text{--}600 \times 1200\text{--}2500\mu$ ; ostioles raised or medium papillate. Asci not seen. Spores gibbous to navicular, narrow ended, each bearing an obtuse broad or narrow hyaline appendage proximally, medium to dark brown,  $10\cdot0\text{--}17\cdot5 \times 19\cdot5\text{--}37\cdot5\mu$ , ave.  $12\cdot0 \times 24\cdot3\mu$ .

South African Hosts: Unidentified.

Material examined:—

Cunningham 3704; on *Podocarpus*, New Zealand, (1930), (Mill.). Martin 1012; Nature's Valley, Knysna District, Western Cape (1962).

Cultural characters:—

Colonies cottony, coarse, dull white to ochraceous with typical straggling surface. Margin not distinct, entire, pioneer hyphae widely dispersed. Conidia appearing by 7 days but not conspicuous. Stain ochraceous, diffuse. Growth rate moderate, 3·0 mm/day at 25°C.

These characters are similar to those of *N. mediterranea*.

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PLATE VIII. Conidiophores and conidia: *Daldinia*.

1—3. *Daldinia eschscholzii*; variation in conidiophores ( $\times 210$ ). Inset: Spores ( $\times 540$ ). 4. *Daldinia bakeri* ( $\times 210$ ). (Ignore oil droplets). 5—7. *Daldinia vernicosa*; variation from complex to simple conidiophores ( $\times 210$ ). 8, 9. *Daldinia concentrica* ( $\times 210$ ). 10. *Daldinia concentrica*; detail of fertile branches ( $\times 540$ ). 11. *Daldinia concentrica*; secondary mycelium (reticulate-tentacular) typical of genus ( $\times 210$ ). 12, 13. *Daldinia occidentale* ( $\times 210$ ).



Microscopic characters:—

Primary mycelium uniform, rather narrow, marginal hyphae up to  $3.0\mu$  in diameter. Secondary mycelium as for *N. uniapiculata*, colourless to light brown, loosely organized,  $2.2$ – $5.3\mu$  diameter.

Conidiophores and conidia (Plate IX: 5–7):—

Conidiophores colourless, short, with smooth walls, atypical for the species group;  $33$ – $90 \times 2.0$ – $2.5\mu$ . Main axes are distally branched ternately to the first or second degree; fertile branches often crowded, swollen clavate, in trident formation with unspecialized or slightly swollen heads;  $4.3$ – $6.8 \times 2.2$ – $3.7\mu$ . Conidia acrogenous, sessile, narrow clavate, white en masse,  $2.7$ – $3.7 \times 4.3$ – $5.0\mu$ , ave.  $3.3 \times 4.7\mu$ .

#### 10. *Numulariola atropunctata* (Schw. ex Fr.) House

- House H. D. N.Y. State Mus. Bull. 266, 49, (1925)  
 sub *Anthostoma atropunctata* (Schw.) Saccardo  
 Saccardo P. A. Sylloge Fungorum 1, 295, (1882).  
 sub *Diatrype atropunctata* (Schw.) Berk.  
 Berkeley M. J. Trans. Linn. Soc. 22, 269, (1858)  
 sub *Hypoxyton atropunctatum* (Schw. ex Fr.) Cke.  
 Cooke M. C. Grevillea 11, 138, (1883). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 89, (1887); N. Amer. Pyren. 650, (1892). Miller J. H. Mycologia 20, 324, (1928); World Species of *Hypoxyton* 114, (1961). Owens C. E. Proc. Indiana Acad. Sci. 1911, 300, (1912). Shear C. L. Lloydia 8, 259, (1945).  
 sub *Nummularia atropunctata* von Hohnel  
 von Hohnel F. Ann. Mycol. 16, 219, (1918). Lloyd C. G. Myc. Writ. 7, 1352, (1925)  
 sub *Sphaeria atropunctata* Chw.  
 Fries E. M. Systema Mycol. 351, (1823). Schweinitz L. v. d. Synops Fung. Car. Sup. 31, (1822).

Stromata aplanate and widely effused with convex surface,  $10$ – $27 \times 80$ – $140 \times 0.5$ – $0.6$  mm. Ectostroma persistent and well developed, smooth, white and corky, interrupted only by the black papillate ostioles. Entostroma carbonaceous, black, rarely exposed. Perithecia immersed, oval,  $200$ – $300 \times 300$ – $400\mu$ ; ostioles minutely papillate. Asci cylindric,  $120$ – $200 \times 14$ – $20\mu$ ; stipes  $13$ – $31\mu$ . Spores oval elliptic, equilateral, dark brown,  $9.5$ – $17.0 \times 18.0$ – $34.5\mu$ , ave.  $12.7 \times 27.1\mu$ .

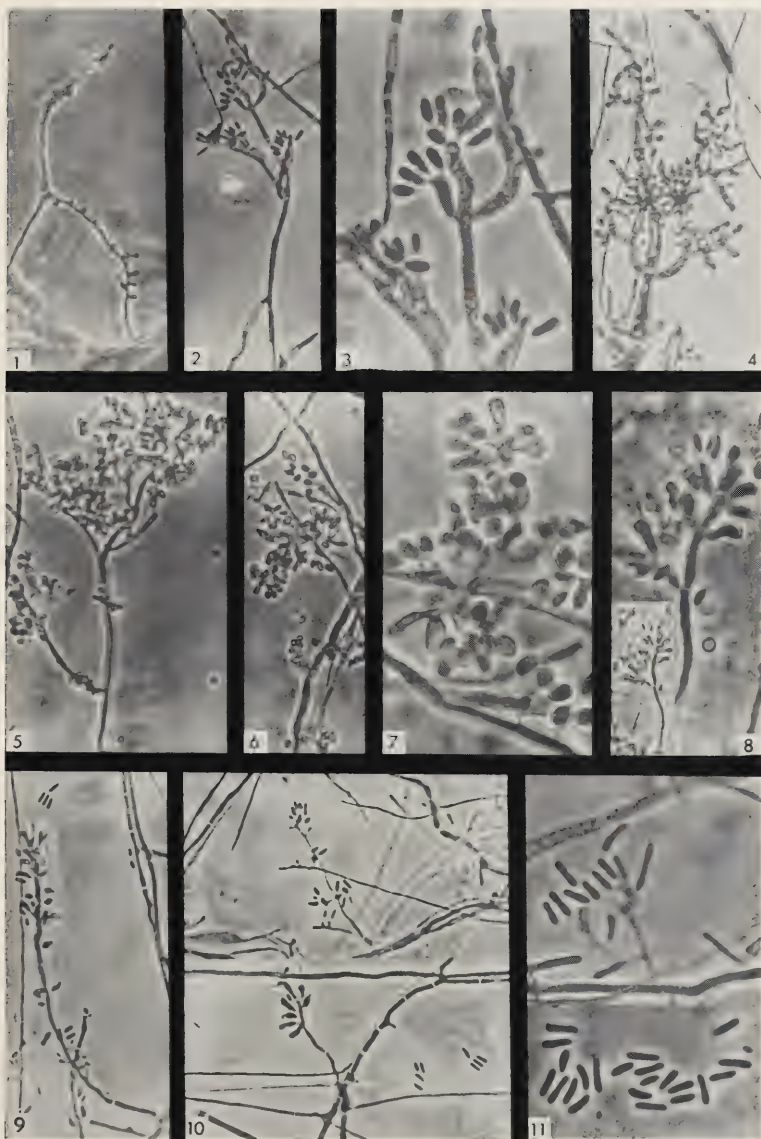
Material examined:—

A large quantity of material in the herbaria cited. Martin 625 ex Barnett & Stipes; Morgantown, West Va., U.S.A., (1961). Martin 1124, 1138, 1182; Lake Ozark, Mo., U.S.A., (1962).

#### PLATE IX. Conidiophores and conidia: *Numulariola*.

1. *Numulariola polysperma*: vesiculate mycelium ( $\times 210$ ). 2. *Numulariola atropunctata* ( $\times 210$ ). 3. The same: detail of (2) ( $\times 540$ ). 4. *Numulariola exutans* ( $\times 210$ ). 5, 6. *Numulariola pithodes* ( $\times 210$ ). 7. The same: detail of (6) ( $\times 540$ ). 8. *Numulariola punctulata* var. *obconica*. Simple conidiophore ( $\times 540$ ). Inset: whole conidiophore ( $\times 210$ ). 9, 10. *Numulariola comedens*; *Acrostaphylus* variants approaching *Basidiobotrys* ( $\times 210$ ). 11. The same: detail ( $\times 540$ ). Inset: Cylindric spores ( $\times 540$ ).





## Cultural characters:—

Colonies cottony, with the usual coarse texture, dull white. Margin entire, not distinct, hyphae widely dispersed. Conidia apparent by 7 days but not conspicuous. Stain greenish brown. Growth rate extremely rapid, 12·3 mm/day at 25°C.

## Microscopic characters:—

Primary mycelium undiagnostic; marginal hyphae up to 3·1μ in diameter.

## Conidiophores and conidia (Plate IX: 2, 3):—

Conidiophores less distinct than other species, with smooth walls, but tinted dull brown, 37—240 × 5·0—5·5μ, unbranched or branched dichotomously up to the second degree over their entire length. Fertile branches clavate, lying freely, heads unspecialized, 7·5—15 × 3·1—3·7μ. Conidia acrogenous, sessile or on stout sterigmata, oval or botuliform with truncate bases, white en masse, 2·5—3·1—4·2—7·3μ, ave. 2·6 × 4·8μ, ave 2·6 × 4·8μ.

11. *Numulariola mediterranea* (DN) Martin nov. comb. (Plate III: 5, 6)

sub *Diatrype clypeus* Berk.

Berkeley M. J. *Grevillea* 4, 95, (1876)

sub *Hypoxylon clypeus* Curt.

Curtis Geol. & Nat. Hist. Survey NC III, 140, (1867). Ellis J. B. & B. M. Everhart N. Amer. Pyren. 627, (1892)

sub *Hypoxylon mediterraneum* (DN) Miller

Miller J. H. *Mycologia*, 33, 75, (1941); *Bothalia*, 4, 254, (1942); *World Species of Hypoxylon* 116—118, (1961)

sub *Hypoxylon regium* DN

De Notaris G. *Hedwigia* 2, 169, (1863); *Sferiacei Italici* 15, (1863)

sub *Hypoxylon repandoides* Fuckel

Bizzozero G. *Flor. Veneta critt.* 1, 2101, (1885)

Fuckel L. *Symb. Myc.* 236, (1869—1870)

sub *Hypoxylon sertatum* Dur. & Mont.

Montagne J. F. C. *Syll. Crypt.* 214, (1856)

sub *Hypoxylon stigmatum* Cke.

Cooke M. C. & J. B. Ellis *Grevillea* 7, 4, (1878). Ellis J. B. & B. M. Everhart *Jour. Mycol.* 4, 89, (1887); N. Amer. *Pyren.* 651, (1892)

sub *Nummularia clypeus* Cke.

Cooke M. C. *Grevillea* 12, 6, (1883). Miller J. H. *Mycologia* 20, 323, (1928). Rehm H. *Leafl. Philipp. Bot.* 6, 1943, (1913). Rick J. *Brotéria ser. bot.* 25, 41, (1931). Shear C. L. *Mycologia* 33, 321, (1941)

Theissen F. *Ann. Mycol.* 7, 11, (1909)

sub *Nummularia regia* (DN) Sacc.

Oliviera B. D. *Rev. Agron.* 19, 16, (1931). Saccardo P. A. *Syll. Fung.* 1, 400, (1882).

Traverso J. B. *Flora Ital. Crypt.* 1, 58, (1906)

sub *Nummularia repandoides* (Fckl.) Sacc.

Lloyd C. G. *Myc. Writ.* 6, 882, (1919). Rabenhorst G. L. *Krypt. flor. Deutsch. II*, 850, (1887). Saccardo P. A. *Sylloge Fungorum* 1, 397, (1882)

Sydow H. & F. Petrak *Ann. Mycol.* 20, 186, (1922)

sub *Nummularia sertata* (Dur. & Mont.) Cke.

Cooke M. C. *Grevillea* 11, 126, (1883)

sub *Sphaeria clypeus* Schw.

Schweinitz L. v. d. *Syn. Fung. Car. Sup.* 31. 31, (1822)

sub *Sphaeria mediterranea* DN

De Notaris G. Microm. Ital. Sec. 6, 96, (1851)

sub *Sphaeria sertata* Dur. & Mont.

Durieu de Maisonneuve M. & J. F. C. Montagne Explor. Alger. I, 455, (1846)

Stomata usually widely effused, aplanate, with a flat or slightly convex matt surface,  $7-144 \times 15-300 \times 0.6-2.2$  mm. Ectostroma dull brown to grey, somewhat granulate, feebly persistent, usually merging with the entostroma beneath. Entostroma carbonaceous, dull brown to black. Perithecia immersed, close crowded and flattened due to pressure, oval,  $200-600 \times 400-1000\mu$ ; ostioles usually conspicuously conic papillate. Asci cylindric, short stipitate or nearly sessile,  $105-140 \times 8-11\mu$ ; stipes  $7-38\mu$ . Ascal plugs discoid to cylindric, sometimes rather attenuated and atypical for the group. Spores elliptic equilateral, gibbous or navicular, dark brown to black, characteristically a rich chestnut,  $5.0-14.5 \times 10.5-26.5\mu$ , ave.  $8.0 \times 17.4\mu$ .

South African Hosts: *Maytenus buxifolia*, *Olea capensis*, *Vepris lanceolata*.

Material examined:—

A large quantity of material in the herbaria cited. Martin 19, 31, 427; Nature's Valley, Knysna District, Western Cape, South Africa (1958, 1959). Martin 623 ex Barnett & Stipes; Morgantown, West Va., U.S.A., (1961). Martin 782, 783; O'Brien, N. Calif., U.S.A., (1961). Martin 1026, 1027. Fillmore, Calif., U.S.A., (1962). Martin 1058; Santa Paula Mtn., Calif., U.S.A., (1962). Martin 1108; Columbia Mo., U.S.A., (1962). Martin 1181, 1184, 1187; Lake Ozark, Mo., U.S.A., (1962). Martin 1618, 1619; Pine Meadow, Rockland Co., NY State, U.S.A., (1963). Martin 1831; Santa Anita Canyon, Los Angeles, Calif., U.S.A., (1963). Martin 1832-4; Gorman, Calif., U.S.A., (1963).

Cultural characters (Plate V: 5; Plate VI: 8; See also Martin (1967) p. 214 fig. 5)

Colonies at first appressed felty and subhyaline; later the aerial mycelium thickens to nearly 3 mm in height and becomes opaque, granulate, coarse, dull white to yellow or ochre, sometimes with olive green colouration around the site of inoculation. This species has the straggling appearance of other members of this group; in addition most of the American strains developed vertical tufts of hyphae seen elsewhere as in *N. tinctor*. Margin not distinct, effuse, entire but with widely separated long pioneer hyphae. Conidia produced by 7 days all over the colony surface, white, sometimes fairly conspicuous. Stain ochraceous to red brown or dull buff brown, sometimes initially a delicate pink. Growth rate rapid,  $6.3-13.9$  mm/day at  $25^{\circ}\text{C}$ . Growth on other media similar but less luxuriant on Czapek and with a more intense purple ochre hue.

Cultures of this species and *N. merrillii* are very similar when both well grown, and can only be distinguished by the following features:—

1. Plate cultures of *N. mediterranea* are white subhyaline when 2 days old, while those of *N. merrillii* are more opaque.
2. Czapek bottle cultures of *N. mediterranea* are distinguished by deep ochre yellow to brown mycelium and initial purple stain. Corresponding cultures of *N. merrillii* are not as strikingly coloured.

Microscopic characters (Fig. 1: 2, 10):—

The microscopic characters easily distinguish this species from its nearest relatives. Primary mycelium comprises stout hyphae with much narrower short curled side branches, and the diameter of the marginal hyphae extends to  $6.6\mu$ . The secondary mycelium is loose, ropy or reticulate, composed of light brown stout hyphae  $1.8\text{--}9.7\mu$  in diameter, larger on the whole than the corresponding ones in *N. merrilli*.

Conidiophores and conidia (Plate X: 3—6; See also Martin (1967) p. 230, fig. V: 4, 9 and 10):—

This species shows enormous variation in size, shape and construction of the conidiophores, ranging all the way from a simple *Sporothrix* type through *Acrostaphylus* to the extremely complex *Basidiobotrys*. The conidia may be produced in a group from the side of an ordinary unbranched and undifferentiated hypha (*Sporothrix* type I) in which case no conidiophore is strictly distinguishable, or from the apices of distinct fertile branches, often thumb-shaped, borne sporadically or from the distal parts of organized conidiophores. Only in the *Basidiobotrys* type is the wall of the conidiophores warted and tinted amber. The *Acrostaphylus* conidiophores are  $16\text{--}630 \times 1.8\text{--}3.7\mu$ , branched up to the second degree; 2—4 fertile branches arising at a node. Fertile branches are narrow or swollen, clavate or elliptic, lying freely or in trident formation,  $3.0\text{--}35 \times 1.6\text{--}5.6\mu$ . Conidia arise indiscriminately, in side-groups, or are acrogenous or pleuracrogenous, sessile or borne on sterigmata, thin-walled or thick-walled, botuliform, oval or clavate, white to fawn or dark brown en masse,  $1.2\text{--}3.9 \times 3.7\text{--}9.6\mu$ , ave  $2.5 \times 5.5\mu$ . South African strains had somewhat wider conidia than the American ones cultured.

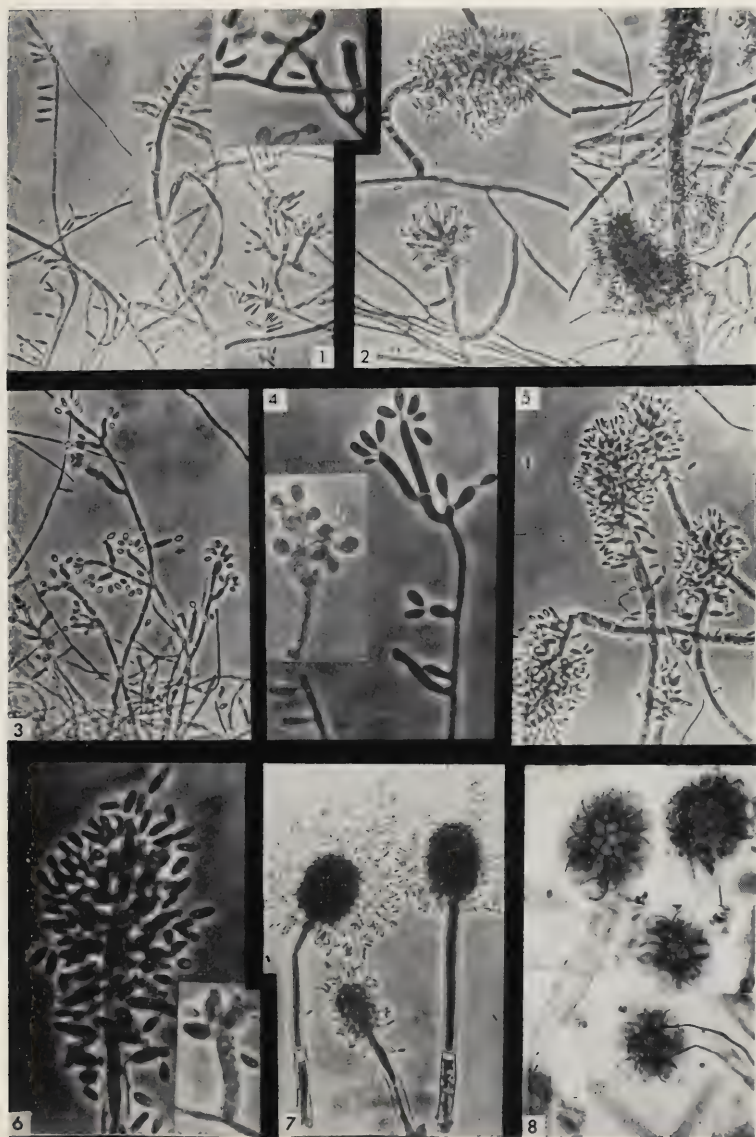
The *Basidiobotrys* type was observed in one strain only (1026), from America. The conidiophores comprises a stout axis  $45\text{--}155 \times 3.0\text{--}4.5\mu$  with a spoon shaped apex bearing up to 52 clavate secondaries giving rise to the fertile branches by dichotomous or ternate branching, giving the overall impression of a bottle-brush. The fertile branches are themselves clavate, lying free or in trident formation,  $6.2\text{--}10.6 \times 3.1\text{--}3.7\mu$ . Conidia are strictly acrogenous or pleuracrogenous, sessile, narrow clavate white en masse,  $1.2\text{--}1.5 \times 4.3\text{--}5.6\mu$ , ave.  $1.5\text{--}5.0\mu$ .

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PLATE X. Conidiophores and conidia: *Numulariola* continued.

1—2. *Numulariola tinctor*. 1. Left and right: *Acrostaphylus conidiophores*. Centre: developing *Basidiobotrys* conidiophore ( $\times 210$ ). Inset: detail of fertile branches ( $\times 540$ ). 2. *Basidiobotrys conidiophores* ( $\times 210$ ). At right, conidiophores in sympodial formation. 3—6. *Numulariola mediterranea*. 3. *Acrostaphylus conidiophores* ( $\times 210$ ). 4. Detail of *Acrostaphylus* ( $\times 540$ ). Inset: The "thumb" type of fertile branch. 5. *Basidiobotrys* conidiophores ( $\times 210$ ). 6. Detail of (5) ( $\times 540$ ). 7—8. *Numulariola punctulata*. 7. *Basidiobotrys* conidiophores ( $\times 210$ ). 8. Detail of 7 (bright field) ( $\times 540$ ).







12. *Numulariola punctulata* (Berk. & Rav.) Cke.

sub *Diatrype punctulata* Berk. & Rav.

Berkeley M. J. *Grevillea* **4**, 94, (1876)

sub *Hypoxylon punctulatum* (Berk. & Rav.) Cke.

Cooke M. C. *Grevillea* **11**, 138, (1883); Handbook of Australian Fungi 295, (1892).

Miller J. H. World Species of *Hypoxylon* 109, (1961)

Winter H. G. & C. H. Demetrio *Hedwigia* **24**, 195, (1885)

sub *Nummularia punctulata* (Berk. & Rav.) Sacc.

Chardon C. E. *Mycologia* **13**, 296, (1922). Ellis J. B. & B. M. Everhart *Jour. Mycol.*

**4**, 90, (1887); N. Amer. *Pyren.* 627, (1892). Lloyd C. G. *Myc. Writ.* **7**, 1311, (1924). Miller J. H. *Mycologia* **20**, 325, (1928)

Rick J. *Broteria ser. bot.* **25**, 44, (1931). Saccardo P. A. *Syll. Fung.* **1**, 399, (1882).

Stromata aplanate, widely effused, flat to convex, with a matt or glossy surface, 9.0—150 × 13—200 × 0.5—1.0 mm. Ectostroma dull brown when persistent at maturity; entostroma carbonaceous, dull brown to black. Perithecia close crowded, immersed, oval, 300—400 × 400—500 $\mu$ ; ostioles umbilicate, sometimes each one seated at the base of a depression. Asci cylindric, 75—125 × 6.9 $\mu$ ; stipes 10—51 $\mu$ . Spores cylindric, oval or elliptic, equilateral, amber to colourless, hyaline 3.5—5.5 × 7.0—10.5 $\mu$ , ave. 4.1 × 7.8 $\mu$ .

Variety *obconica*: spores with proximal ends narrow. This character is not accompanied by other sufficiently distinguishing characters to make a separate species.

Material examined:—

A wide range of material in the herbaria cited. Martin 622 ex Barnett & Stipes; Morgantown, W. Va., U.S.A., (1961). Martin 639 ex Lowy; Baton Rouge, La., U.S.A., (1961). Martin 1620; Pine Meadow, Rockland Co., NY State, U.S.A., (1963).

Cultural characters:—

Colonies cottony to somewhat fleecy, coarse, with straggling surface and vertical tufts, ochraceous. Margin not distinct, entire; hyphae widely dispersed. Conidia apparent by 7 days but not conspicuous. Stain ochraceous to greenish brown. Growth rate moderate to fast, 3.6—7.1 mm/day.

Microscopic characters:—

Primary mycelium rather broad, marginal hyphae up to 12 $\mu$  in diameter. Secondary mycelium loosely organized, light brown, 3.0—5.3 $\mu$  in diameter. Imperfect Stage (Plate IX: 8; Plate X: 7, 8; See also Martin (1967) p. 230, fig. 8)

Barnett H. L. *Mycologia* **49**, 588—595, (1957).

Conidiophores belong to *Acrostaphylus* or *Basidiobotrys*; the latter type, as in *N. mediterranea* not universal. The *Acrostaphylus* type only belongs to variety *obconica* and is weakly differentiated, colourless, with smooth walls, 30—150 × 2.0—3.0 $\mu$ , branched dichotomously or ternately to the first degree distally or at the ends of the main axes. Fertile branches are swollen, clavate to obovate,

lying freely or in trident formation,  $4.3-9.0 \times 2.5-4.3\mu$ . Conidia acrogenous, on slender sterigmata, narrow clavate, fawn brown,  $2.5-3.8 \times 3.7-5.6\mu$ , ave.  $3.0 \times 4.8\mu$ .

The *Basidiobotrys* type is more clearly differentiated, also smooth walled but tinted amber,  $135-510 \times 6.2-7.5\mu$ , branched to the first degree only; main axes distinctly clavate with 33-80 fertile branches clustered at the ends in "bottle-brush" formation. Fertile branches swollen, elliptic rather than clavate, lying freely,  $3.7-7.5 \times 2.5-3.1\mu$ . Conidia acrogenous, on slender sterigmata, long cylindric, ochraceous,  $1.2-1.8 \times 3.7-5.6\mu$ , ave.  $1.6 \times 4.7\mu$ .

**13. *Numulariola tinctor* (Berk.) Martin nov. comb. (Plate IV: 1-3, 13)**

sub *Diatrype tinctor* (Berk.) Sacc.

Saccardo P. A. Syll. Fung. 1, 200, (1882)

sub *Hypoxyton tinctor* (Berk.) Cke.

Cooke M. C. Grevillea 11, 133, (1883). Ellis J. B. & B. M. Everhart Jour. Mycol. 4, 90, (1887). Lloyd C. G. Myc. Writ. 7, 1311, (1924)

Miller J. H. World Species of *Hypoxyton* 118, (1961)

sub *Nummularia subapiculata* E. & E.

Ellis J. B. & B. M. Everhart Jour. Mycol. 5, 22, (1890)

sub *Nummularia tinctor* (Berk.) Cke.

Cooke M. C. Grevillea 11, 133, (1883). Ellis J. B. & B. M. Everhart Bull. Lab. Nat. Hist. Univ. Iowa 2, 405, (1893). O'Neal C. E. Proc. Indiana Acad. Sci. 1914, 240, (1914). Saccardo P. A. Ann. Mycol. 9, 249, (1911).

sub *Sphaeria tinctor* Berk.

Berkeley M. J. Hooker's London Jour. of Bot. 4, 311, (1845).

Stromata aplanate, usually widely effused, with a flat matt surface,  $9.0-30 \times 17-50 \times 0.5-2.0$  mm. Ectostroma usually retained at least partly at maturity, burgundy brown; entostroma carbonaceous, well developed, dark brown to black. Perithecia immersed, close crowded, elliptic,  $300-400$   $700-1500\mu$ , often several to one ostiole; ostioles umbilicate when entostroma is present, being immersed in it, papillate when entostroma has been sloughed off. Asci cylindric,  $120-195 \times 9-14\mu$ ; stipes  $21-60\mu$ . Ascus plugs discoid to cylindric, the latter splitting horizontally into proximal and distal halves; sometimes the proximal half is enclosed between coronet shaped projections. Spores elliptic, gibbous to navicular, broad or narrow rounded, amber, hyaline to subhyaline,  $5.0-9.5 \times 10.5-23.0\mu$ , ave.  $7.4 \times 16.5\mu$ . This species grows commonly on *Platanus occidentale* in North America.

Material examined:—

A wide range of material in the herbaria cited. Martin 589; Palmdale, California, U.S.A., (1961). Martin 1025; Fillmore, Calif., U.S.A., (1962). Martin 1030, 1031; Montezuma's Castle, Arizona, U.S.A., (1962). Martin 1056, 1057; Mill Creek, San Bernardino, Mtn., Calif., U.S.A., (1962). Martin 1092, 1093; Columbia, Mo., U.S.A., (1962). Martin 1140, 1161; Lake Ozark, Mo., U.S.A., (1962). Martin 1502, 1504, 1505, 1522, 1524, 1572; San Blas, Nayarit, Mexico, (1962). Martin 1830; Gorman, Calif., U.S.A., (1963).

Cultural characters (See Martin (1967) p. 212, fig. 4):—

Colonies cottony, with the usual coarse straggling appearance, also with

vertical tufts of hyphae, dull white to ochre. Mycelial aggregates sometimes present in slight quantity. Margin not distinct, entire; hyphae widely dispersed. Conidia appear early or late but are not conspicuous. Stain amber to dull buff brown, not conspicuous, as in *N. uniapiculata*. Growth rate rapid, 4.9–8.6 mm/day at 25°C.

Microscopic characters:—

Primary mycelium undiagnostic; marginal hyphae up to 3.7  $\mu$  in diameter. Secondary mycelium uniform, loosely organized, 3.0–10.5  $\mu$  in diameter.

Conidiophores and conidia (Plate X: 1, 2; See also Martin (1967) p. 230, figs. 5–7)

The great majority of strains studied showed both the *Acrostaphylus* and *Basidiobotrys* types of conidiophore which were clearly distinct from the vegetative mycelium due to amber or dark brown tint and warted walls. The conidiophores were uniformly narrow or broad clavate apices, and were unbranched or branched dichotomously to the second degree, branched all over, distally or strictly apically in “bottle-brush” formation, 85–410  $\times$  3.7–6.0  $\mu$ . Fertile branches swollen, clavate or elliptic, lying freely, 50–108 per head, 5.0–11  $\times$  2.5–4.3  $\mu$ . Conidia acrogenous, sessile or on slender sterigmata, pyriform, white to yellow en masse, 1.2–2.5  $\times$  5.6–10.0  $\mu$ , ave. 2.0–7.1  $\mu$ .

#### 14. *Numulariola comedens* (Ces.) Martin nov. comb.

sub *Hypoxylon comedens* (Ces.) Cke.

Cooke M. C. *Grevillea* **11**, 126, 1883. Miller J. H. *World Species of Hypoxylon* 107, (1961)

sub *Nummularia comedens* Cesati

Cesati V. *Atti R. Accad. Scienze Fisich e Matem.* **8**, 19, (1879).

Stromata aplanate; usually fairly large but sometimes restricted, with a flat or concave smooth, dull or shiny surface, 4.0–17  $\times$  5.5–55  $\times$  1.2–1.5 mm. Ectostroma absent at maturity; entostroma black carbonaceous, well developed. Perithecia at centre of stroma, surrounded by large sterile margin, immersed, oval-elliptic, close-crowded, 1–10 per ostiole, 200–600  $\times$  100–1200  $\mu$ ; Ostioles either not visible or uniliculate with raised rims. Asci cylindric, 100–180  $\times$  6–11  $\mu$ ; stipes 30–56  $\mu$ . Spores elliptic, equilateral or gibbous, broad or narrow rounded, amber, subhyaline to translucent, 5.0–9.0  $\times$  10.5–23.0  $\mu$ , ave. 6.4  $\times$  15.5  $\mu$ . This species is close to *N. tinctor*, differing in extent of sterile stroma, many perithecia converging towards 1 ostiole, and in the spore characters. It is doubtfully separable from *N. cyclisca*.

Material examined:—

Martin 932, 933, 938; Mazatlán, Sinaloa, Mexico, (1961).

Cultural characters:—

Colonies cottony with the usual coarse straggling surface, also with vertical tufts, dull white to ochre. Mycelial aggregates absent. Margin not distinct, entire, hyphae widely dispersed. Conidia only develop when old. Stain dull buff brown to olive green, more conspicuous than in *N. tinctor*. Growth rate rapid, 4.0 mm/day.

Microscopic characters:—

Primary mycelium undiagnostic; marginal hyphae broad, up to  $5.0\mu$  in diameter. Secondary mycelium absent: a feature unusual in this species group.

Conidiophores and conidia (Plate IX: 9—11):—

This species has so far shown the *Acrostaphylus* type of conidiophore and some intermediate with *Basidiobotrys*. The conidiophores resemble those of *N. tinctor*, and are colourless, with smooth or warted walls,  $35\text{--}120 \times 1.2\text{--}2.5\mu$ , branched dichotomously to the first or second degree distally or at the apices of the main axes. Fertile branches relatively few to several loosely aggregated per head, narrow or swollen elliptic, lying free, with unspecialized apices,  $4.3\text{--}22.5 \times 1.5\text{--}3.1\mu$ .

Conidia acrogenous or in side-groups off the hyphae, sessile, narrow clavate, white en masse,  $1.2\text{--}2.5 \times 5.0\text{--}7.5\mu$ , ave.  $2.2 \times 5.9\mu$ .

#### ACKNOWLEDGEMENTS

The writer wishes to thank, in addition to those cited by Martin (1967), Mr. Max Ulrich of the Photography Dept., S.A.I.M.R., in preparing the illustrations.

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## A NEW COMBINATION IN *LACHENALIA* WITH NOTES ON THE SPECIES

W. F. BARKER

(*Compton Herbarium, Kirstenbosch*)

### ABSTRACT

A new combination *Lachenalia pearsonii* (Glover) Barker is made, and the name *Lachenalia Pearsoni* in use for a cultivar is found to be a nomen nudum.

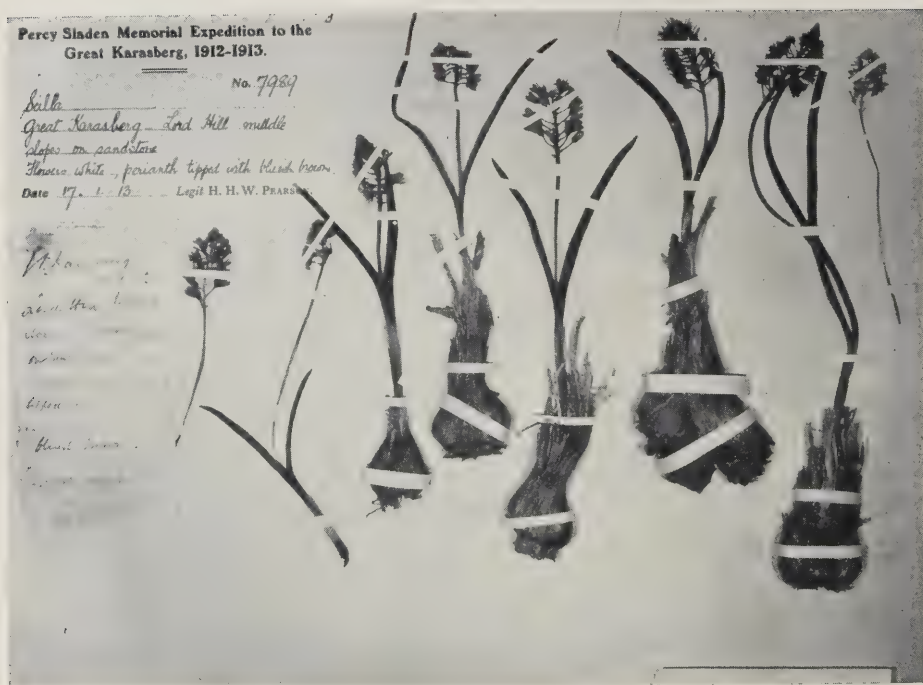
***Lachenalia pearsonii* (Glover) Barker comb. nov.**

*Scilla pearsonii* Glover, in Ann. Bolus Herb. 1. 105 (1915)—basionym.

*Scilla pearsonii* was described by Miss R. Glover from specimens which were collected by Professor H. H. W. Pearson while on the Percy Sladen Memorial Expedition to the Great-Karasberg, S.W. Africa 1912–1913. The holotype sheet H. H. W. Pearson No 7989 is in the Bolus Herbarium, and attached to it is a field label in Pearson's hand on which the locality is given as Gt. Karasberg, Lord Hill. This name cannot be traced on any map, but in her description Miss Glover cites the locality as Central Karasberg, Scharfenstein which on modern maps appears as Schroffenstein, 3027AD on the grid system.

In July 1963 when examining the sheet Mrs. A. A. Mauve of the Botanical Research Institute, Pretoria, suggested that it would be better placed in the genus *Lachenalia*. On dissecting a young flower, it was found, that in contrast to that of *Scilla* which has polypetalous flowers with almost equal segments, it had a short tube with the filaments of the stamens adnate to it, and the segments of the two perianth whorls differed in width and shape. I have therefore decided to transfer the species and to make the new combination *Lachenalia pearsonii* (Glover) Barker. It is only known from the type locality and the type collection, and has some of the smallest and most inconspicuous flowers in the genus.

For a number of years a showy plant with large orange-yellow pendulous flowers with a red base and red tips to the inner segments, has been cultivated in public parks and private gardens under the name of *Lachenalia Pearsoni*. It is said to be the result of a cross between *L. Nelsoni* (itself a hybrid) and *L. bulbifera* (*L. pendula*) which was raised by Mr. Pearson, curator of the Parks



*Lachenalia pearsonii* (Glover) Barker. H. H. W. Pearson 7989, type sheet of *Scilla pearsonii* Glover in Bolus Herbarium.

Photo: J. P. Rourke

and Gardens of Auckland City, New Zealand, after whom it was named. As the name has not been validly published with a Latin description as required by the International Code of Botanical Nomenclature, Article 40, it must be considered to be a nomen nudum and the epithet *pearsonii* to be correctly applied to Pearson No. 7989 as the holotype.

#### ACKNOWLEDGEMENTS

Sincere thanks are due to Professor E. A. Schelpe of the Bolus Herbarium for the loan of the type sheet and for his kindly advice, to Mrs. A. A. Mauve for bringing the matter to my notice and to Mr. J. P. Rourke for the accompanying photograph.

## NOTES ON THE NOMENCLATURE OF LEUCOSPERMUM R.BR.: II.

J. P. ROURKE

(*Compton Herbarium, Kirstenbosch*)

### ABSTRACT

Two new combinations, *Leucospermum rodolentum* (Salisb. ex Knight) Rourke and *Leucospermum calligerum* (Salisb. ex Knight) Rourke, are proposed. Additional evidence is presented to support the view that R. A. Salisbury was responsible for the taxonomic part of Joseph Knight's book, *On the cultivation of the plants belonging to the natural order Proteaceae*. London, 1809.

### INTRODUCTION

Several new name combinations in *Leucospermum* have already been published by the present author prior to the appearance of a complete revision of the genus. In order to bring the nomenclature of *Leucospermum* up to date in accordance with the currently accepted rules, two further combinations must be made. Only the immediately relevant synonymy is given in each case. All types quoted have been seen by the present author. This paper concludes the series "Notes on the nomenclature of *Leucospermum*".

***Leucospermum rodolentum*** (Salisb. ex Knight) Rourke, comb. nov.

*Leucadendrum rodolentum* Salisb. ex Knight in Knight, Cult. Prot.: 58 (1809)-basionym. Iconotype: Bot. Repos.: t.294 (1803).

*Protea candicans* Andr., Bot. Repos.: t.294 (1803) non Thunberg (1800).

*Leucospermum candicans* (Andr.) Sweet in Sweet, Hortus Suburbanus Londinensis: 21 (1818); Phillips in Fl. Cap. 5: 628 (1912).

Andrews published a brief description and an excellent colour plate of this species which he named *Protea candicans* in 1803 (See Plate 1). Since this name is a later homonym of Thunberg's *Protea candicans* (1800), it must be rejected. *Leucospermum candicans* is also inadmissible as Sweet merely transferred the epithet from *Protea* to *Leucospermum* without providing a description. The next legitimate epithet available is taken from *Leucadendrum rodolentum* Salisb. ex Knight.

***Leucospermum calligerum*** (Salisb. ex Knight) Rourke, comb. nov.

*Leucadendrum calligerum* Salisb. ex Knight in Knight, Cult. Prot.: 60 (1809)-

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Accepted for publication 19th July, 1969.



basionym. Type: Dry places, Twenty-four rivers, *Niven* 41, holotype in herb. Salisbury (K), isotype in herb. J. E. Smith (LINN).

*Protea pubera* L., *Mantissa Altera*: 192 (1771)-nom. superfl. Type: Sheet No. 116.37 (LINN).

*Leucospermum puberum* (L.) R.Br. in Trans. Linn. Soc. Lond **10**: 100 (1810); Phillips in Fl. Cap. **5**: 634 (1912).

When Linnaeus described *Protea pubera* in the *Mantissa Altera* he cited *Leucadendron oleaefolium* Berg. as a synonym, thus making *Protea pubera* L. a superfluous name, which, being illegitimate must be rejected. The next legitimate specific epithet that can be applied to this species is taken from *Leucadendrum calligerum* Salisb. ex Knight, a name given to a collection made by James Niven at Twenty-four rivers (above Porterville C.P.), at which locality it is still common today.

The holotype of *Leucospermum calligerum* (Salisb. ex Knight) Rourke is at Kew and bears the following note in the handwriting of R. A. Salisbury.

"Pubera L. 41 Niven Divaricata 4—5 ft high, dry places 24 rivers district.

It answers to Linne's descr. of his pubera Mant. p.192 but certainly not *L. oleaefolium* Berg. *Calligerum* would be a good name for it."

Stafleau (1967:241) points out that Knight's types are unknown. This is hardly surprising since it is unlikely that Knight ever possessed an herbarium himself. But a high proportion of the names published by Knight can be typified by specimens in Salisbury's herbarium.

Britten (1886) discussed at length the question of the authorship of the taxonomic part of Knight's book "*On the cultivation of the plants belonging to the natural order Proteaceae*" and advanced very convincing evidence from numerous sources to support his contention that R. A. Salisbury was responsible for the text of the greater part of this work.

It is strange that no reference has ever been made to the very revealing clues that are to be found in the notes attached to Salisbury's specimens, now in the Burchell collection at Kew. The notes and manuscript names are invariably the same notes and names which appear in Knight's book. In the example quoted above ("*Calligerum* would be a good name for it"), it is obvious that Salisbury coined the name "*calligerum*" although Knight published it. The agreement between Salisbury's notes and names on his herbarium material and the notes and names in Knight's book is too consistent to be merely coincidental. Indeed, it is possible that Salisbury's annotated herbarium material may well

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#### PLATE I.

The iconotype of *Leucospermum rodolentum* (Salisb. ex Knight) Rourke. Plate 294 from H. C. Andrews' "*Botanists Repository*", published in April 1803. The plant figured had flowered in Hibbert's collection at Clapham in 1802.



constitute the manuscripts referred to by Knight in his preface (pg VII), which he "found so useful in every sheet". This evidence confirms Britten's opinion and clearly demonstrates the very significant part played by Salisbury in the production of Knight's book.

#### ACKNOWLEDGEMENTS

Visits to European herbaria to examine type material were made possible by the award of the Smuts Memorial Fellowship in Botany by the University of Cape Town. I also wish to express my appreciation to Prof. E. A. Schelpe for his advice and guidance on nomenclatural matters.

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## TYPES OF BRUNIACEAE IN THE THUNBERG HERBARIUM

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### ABSTRACT

Checking the identity of the types of the Bruniaceae in the Herb. Thunberg, many of which have been used as basionyms by subsequent authors, has shown that some names have been misapplied, particularly in the genus *Staavia*; one species of *Linconia* must be reduced to synonymy and one new subspecies of *Tittmannia laxa* must be recognised.

#### *Staavia capitella* (Thunberg) Sonder

Holotype: *Thunberg* 5735. "*Brunia capitella*."

This is the correct name for the species referred by Pillans (1947) to *Staavia comosa* (Thunberg) Colozza. *Brunia comosa* Thunberg is represented by two

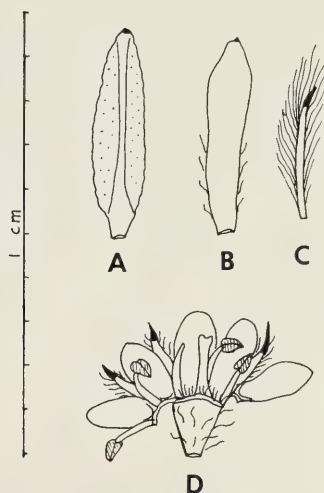


FIG. 1.

"*Brunia capitella*" *Thunberg* 5735.

A: abaxial side of leaf. B: involucre bract. C: bracteole. D: partly dissected flower.

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Accepted for publication 20th July, 1969.

sheets in Herb. Thunberg (5736 & 5737) both of which are *Berzelia lanuginosa* (L.) Brogniart in fruit. Colozza (1905) erroneously applied his new combination to *Staavia capitella* and one must return to the correct application of *Staavia capitella* by Sonder (1862) in the Flora Capensis, of which *Brunia capitella* Thunberg is the basionym.

*Thunberg* 5735 (the holotype) matches most closely *Schlechter* 9842 from Genadendal, quoted under *Staavia trichotoma* by Pillans who misapplied this name to *Staavias* from the Rivier Zonde Einde range. He placed in *Staavia comosa* those plants from the Caledon area with smaller, often laterally placed inflorescences, narrower leaves and linear involucre bracts. In *Staavia trichotoma* he placed those plants from the Rivier Zonde Einde range with larger, usually terminal inflorescences, wider leaves and obtuse bracts. These forms can, however, be connected by intermediate forms from Wildepaardeberg (*Stokoe* 2740), Kaaiaim's Gat (*Esterhuysen* 1886), Villiersdorp (*de Villiers* s.n., *Bolus* 5049, *Esterhuysen* 32063), while *Schlechter* 9842 from Genadendal is the closest match to Thunberg's type of *Brunia capitella*. *Staavia capitella* (Thunberg) Sonder therefore includes both *Staavia comosa* sensu Colozza and *Staavia trichotoma* sensu Pillans.

This variable species can usually be readily distinguished from *Staavia radiata* (L.) Dahl by its hairy disc and poorly differentiated involucre. In the Caledon-Bredasdorp area however, where these two species are sympatric, they approach rather more closely. Since *Staavia radiata* is known to hybridise with *Staavia dodii* Bolus (e.g. *Esterhuysen* 31684) it is likely that some hybridisation and introgression between the more closely related *Staavia radiata* and *Staavia capitella* has occurred. *Staavia radiata* from this area tends to be more hairy in all respects and *Staavia capitella* to have more slender leaves and more prominent involucre bracts. However *Staavia capitella* never has more than a single whorl of coloured bracts and its bracteoles are more robust than the very slender bracteoles of *Staavia radiata* which also has at least two whorls of differentiated bracts, the innermost being small and strikingly spatulate.

***Staavia trichotoma* (Thunberg) Pillans**

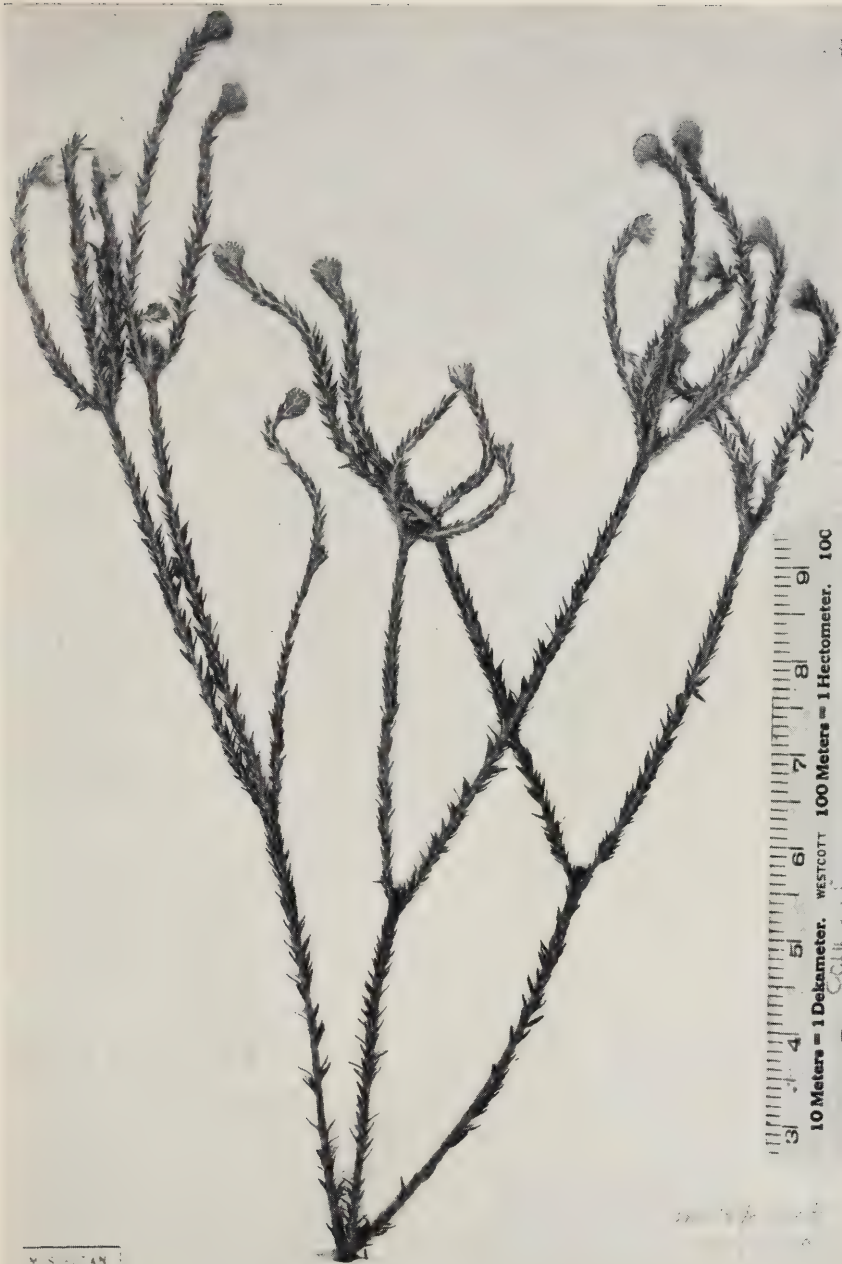
Holotype: *Thunberg* 5543. "Phylica trichotoma."

This species of *Staavia* is only known from three collections. The Herb. Thunberg contains two, the holotype, collected by Masson, and *Thunberg* 5517 labelled "*Phylica globosa*". The third specimen is in the Sonder collection at Melbourne (MEL 27727) and is extensively annotated by Sonder, and because of the annotation "ex Thunberg" is probably a piece of *Thunberg* 5517.

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PLATE 1.

Holotype: *Thunberg* 5543. "Phylica trichotoma".



V. S. S. L. AN.  
JAL. ENNE

*Physcia tripartita*

Thunberg's first description of this species is *Phylica trichotoma* in 1794. Later in the *Dissertatio de Phylica* (1804) he also described *Phylica globosa* while still maintaining *Phylica trichotoma* as a separate species. Sonder (1862) united these two as a single species which he transferred to the genus *Staavia*, incorrectly adopting the later epithet in *Staavia globosa* (Thunberg) Sonder. This was corrected by Pillans (1947) who made the new combination *Staavia trichotoma* (Thunberg) Pillans, but misapplied it to that form of *Staavia capitella* from the Rivier Zonde Einde range, as has been explained above.

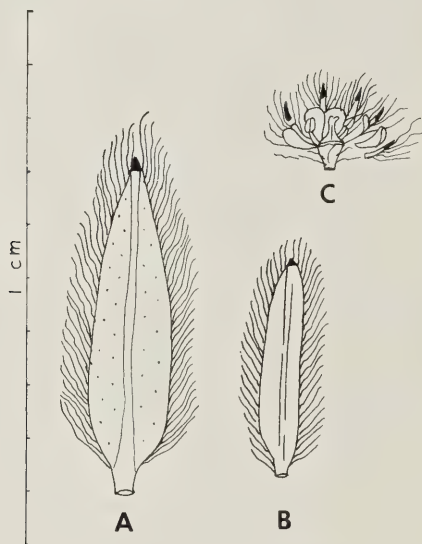


FIG. 2.

"*Phylica trichotoma*" Thunberg 5543.

A: abaxial side of leaf. B: inner side of involucral bract. C: immature flower partly dissected.

*Staavia trichotoma* differs from *Staavia capitella* in having leaves 7–10 mm long which are densely ciliate along the whole margin even in the second year of growth and in having a more globose inflorescence which is invariably terminal, up to 9 mm in diameter (still immature since none of the three specimens has fully developed flowers) with a leafy involucre 4–5 whorls in depth. The innermost bracts are narrowly lanceolate (4 mm long, 1 mm wide) and so densely clothed in hairs externally as to be invisible before dissection because they merge with the densely ciliate disc. The flowers on both the Thunberg and Sonder material are in bud, and therefore one cannot accept Sonder's



distinguishing character of "sepals longer than petals" because this is usual in all *Staavia* buds. Sonder's material carries a note "Genadenthal" but Thunberg gives no locality. Since this "lost" species is most closely allied to *Staavia capitella* a search for it should be made on the Rivier Zonde Einde mountains or possibly the Langeberg, areas visited by Thunberg and Masson on their joint journey.

***Staavia verticillata* (L.f.) Pillans**

Lectotype: Left-hand specimen on *Thunberg 5750*. "*Brunia verticillata*."

In his description of *Brunia verticillata* (1781) Linnaeus the younger placed

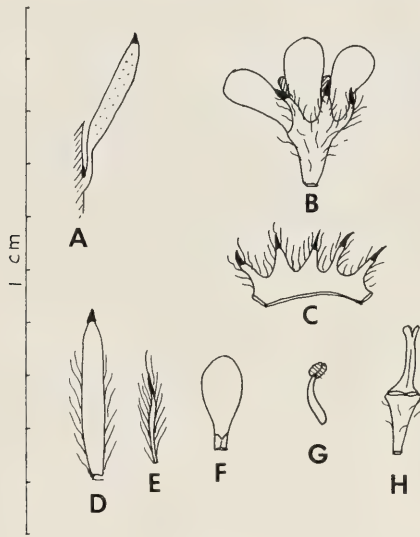


FIG. 3.

"*Brunia verticillata*" *Thunberg 5750* left-hand specimen.

A: leaf attached to stem, showing stipule. B: flower. C: inner side of dissected calyx.

D: involucral bract. E: bracteole. F: petal. G: stamen. H: ovary.

the name Thunberg after the description, but Thunberg's own description was not published till 1794. The two descriptions tally closely and there is no doubt that the two authors were describing the same plant. Since there is no specimen of *Brunia verticillata* in the Linnaean Herbarium, nor among the Linnaean collection in the Riksmuseet Stockholm, Thunberg's specimen of *Brunia verticillata* must be the type. The sheet *Thunberg 5750* however, has on it two

specimens, the right-hand one being *Staavia radiata* (L.) Dahl. This is a species that was recognised by Thunberg, in which he also included the species later referred to *Staavia dregeana* by Presl (1844). In the Herb. Thunberg there are two specimens labelled "*Staavia radiata*", namely Thunberg 5754 which is *Staavia radiata*, and Thunberg 5755 which is *Staavia dregeana*.

Linnaeus the younger was also presumably familiar with *Staavia radiata* which is represented in the Linnaean collections and there are three fairly clear indications in his description that he was referring to the new species and not redescribing *Staavia radiata*. The most obvious difference between *Staavia radiata* and *Staavia verticillata* is the prominent white involucre of the former. Therefore since there is no mention at all of an involucre in the younger Linnaeus' description there seems little doubt as to which of the two species was intended. There is also a leaf difference between the two species for, though *Staavia radiata* has a leaf which is strongly keeled below, it would hardly be described as "triquetris" and the leaves are definitely lanceolate not "obtusis", both descriptive terms which apply appropriately to *Staavia verticillata*. It therefore seems clear that, whatever Thunberg may have intended, Linnaeus the younger's description applies to the left-hand specimen on Thunberg 5750, and this must be taken as the lectotype. This sheet is unusual among the Thunberg collection in that a definite locality is indicated. It bears the inscription "summo Monte Rode Sand supra waterfall. Oct."

**Berzelia squarrosa** (Thunberg) Sonder

Holotype: Thunberg 5749. "Brunia squarrosa."

*Brunia squarrosa*, though misapplied by both Colozza (1905) and Pillans (1947) was correctly interpreted by Sonder (1862) in the Flora Capensis. *Berzelia arachnoidea* (Wendland) Ecklon & Zeyher based on *Brunia arachnoidea* Wendland (1810) has been incorrectly used to designate this species. *Brunia squarrosa* var. *reflexa* Sonder however, has been distinguished as a separate species, *Berzelia rubra* (Willdenow) Schlechtendal.

The Thunberg material has very immature inflorescences on which the flowers are still in an early stage of development, but the arachnoid-pilose young shoots combined with the long leaves (10—15 mm) make the specimen easy to identify and quite distinct from *Berzelia dregeana* Colozza, nor does it have the stout growth of *Berzelia rubra* (Willdenow) Schlechtendal.

**Linconia cuspidata** (Thunberg) Swartz

Holotype: Thunberg 5673. "Diosma cuspidata."

The holotype consists of two specimens both with long (7—13 mm) leaves which are narrowly linear and match shade forms of *Linconia cuspidata* such as *Esterhuysen* 31670 from Baviaanskloof, off Bains Kloof, and *Stokoe* 3550

from the Klein River Mountains, which is probably also a shade form. The flowers on the left-hand twig of Thunberg's material are larger (13 mm) and the bracts on the right-hand twig exceptionally narrow (2.5 mm long, 1 mm wide compared to 2 mm wide on the left-hand specimen). The closest match to the type is *Stokoe* 3550, but the flowers also show an anomalous enlargement of one sepal, similar to that in *Esterhuysen* 31670, which has not been noted except in material from Baviaanskloof, and this is probably the type locality. Thunberg's material is a collection of Masson's and there is a specimen of *Linconia*

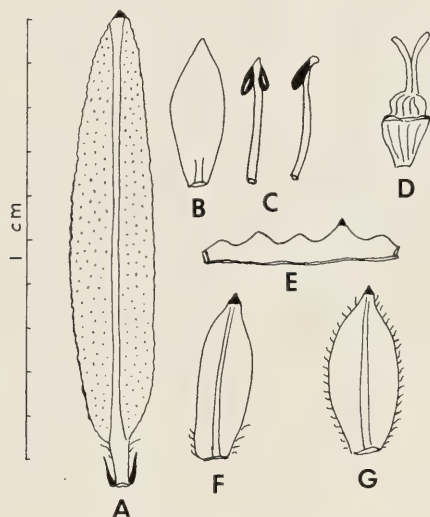


FIG. 4.

"*Diosma cuspidata*" Thunberg 5673.

A. leaf of left-hand specimen showing stipules. B: petal. C: stamen in face and side view. D: ovary. E: calyx. F: bract of left-hand specimen. G: bract of right-hand specimen.

*cuspidata* labelled "ex Thunberg" in the Herb. Retzius at Lund which is probably a portion of the type.

*Linconia cuspidata* is a rare species occurring as small isolated populations or even isolated plants from Baviaanskloof south to the Rooi Els River and eastwards to the Klein River Mountains. There is sufficient material available in the Bolus Herbarium to indicate that there is a considerable range of leaf, bract and flower size. This variation appears to be ecological rather than geographical, as shown by *Stokoe* 4006 and *Esterhuysen* 2618 both from the Somerset Sneekop-Landdrostkop area.

Two species of *Linconia*, in addition to *Linconia alopecuroidea* L., were accepted by Pillans (1947). *Linconia deusta* (Thunberg) Pillans was applied by him to Zeyher 2651 from the Rivier Zonde Einde range, and is conspecific with *Linconia thymifolia* Swartz. Swartz (1810) himself stated that *Linconia thymifolia* was the same as *Diosma deusta* Thunberg (1803) and this is confirmed by his excellent illustration. However, Zeyher 2651 does not match the type of *Diosma deusta*, Thunberg 5674, which is a fruiting specimen of *Linconia cuspidata* matching Esterhuysen 2618 from Somerset Sneeukop in leaf length and bract

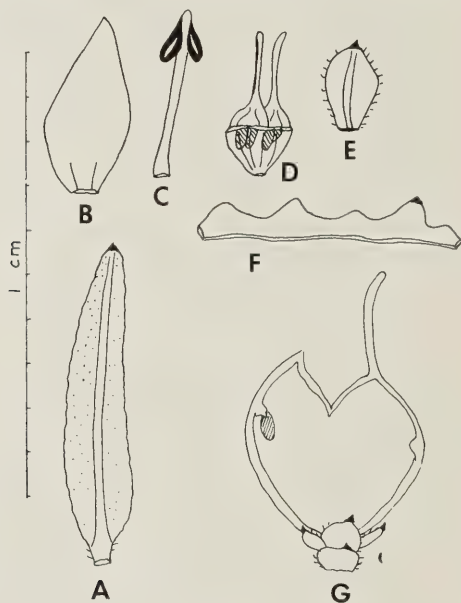


FIG. 5.

"*Diosma deusta*" Thunberg 5674.

A: abaxial side of leaf. B: petal. C: stamen. D: ovary. E: bract. F: calyx. G: half dehiscent fruit with one infertile seed.

shape and size. This Esterhuysen collection was quoted under *Linconia cuspidata* by Pillans. The leaves of the Thunberg material are rather more lanceolate than usual in *Linconia cuspidata*, but certainly do not resemble those of Zeyher 2651. Nor can the latter be regarded as a separate species when the full range of variation is taken into account. The closest match to Zeyher 2651 is Esterhuysen 2619, also from the Landdrostkop area.

Since Thunberg originally published both *Diosma cuspidata* and *Diosma deusta* simultaneously (1803), it is proposed that *Linconia cuspidata* (Thunberg) Swartz, the name already in current use for most of the material, should be retained for this species, reducing *Linconia deusta* (Thunberg) Pillans to synonymy.

***Raspalia phylicoides* (Thunberg) Arnott**

Holotype: Thunberg 5747. "*Brunia phylicoides*".

Here confusion has arisen between two similar species of *Raspalia*, one of

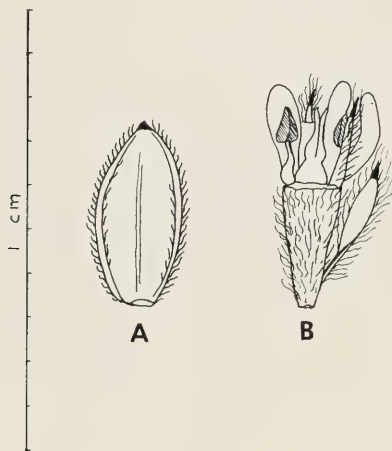


FIG. 6.

"*Brunia phylicoides*" Thunberg 5747.

A: adaxial surface of leaf. B: partly dissected flower.

which is extremely variable. The more robust species has obtuse leaves 4–6 mm long, very hairy abaxially and glabrous adaxially and flowers about 4 mm long. This is the species to which Thunberg applied the name "*Brunia phylicoides*," and the nearest match to the type is *Bolus* 135 from Sir Lowry's Pass. The other more slender species varies considerably, depending on whether it is growing in thick bush or coppicing after fire (e.g. Powrie 174A & 174B) and, while the leaves are less hairy abaxially than the preceding species, they are usually densely hairy adaxially, but towards the eastern end of its distribution the leaves may be glabrous adaxially (e.g. *Ecklon & Zeyher* 1064 from Zwarteberg, Caledon). Even in the most robust forms of this second species the leaves do



not exceed 3 mm and are definitely lanceolate and the flowers are usually only 3 mm in size with more slender petals than the preceding species.

Sonder (1862) treated these two as varieties of a single species and misapplied the epithet *phylicoides* to the slender one, illegitimately creating a variety *robusta* Sonder based on the Thunberg type of *Brunia phylicoides*. This is clearly stated in the Flora Capensis and confirmed by two specimens annotated by Sonder in the Sonder collection at Melbourne. MEL 27719 is annotated "vera *Brunia phylicoides* Herb. Thunb." and "var *robusta*" and is probably a portion of the Thunberg type. MEL 27718 is a specimen of the slender species. In addition there is a sheet, unannotated by Sonder, MEL 27717 Ecklon & Zeyher 1064, the number quoted by Presl (1844) as *Raspalia passerinoides* (Schlechtendal) Presl, based on *Brunia passerinoides* Schlechtendal (1831). This is also the slender species.

Pillans (1947) recognised Sonder's two varieties as two species but misapplied the epithet *phylicoides* to the slender one, incorrectly concluding that var *robusta* Sonder was the more robust form assumed by this species when not coppicing.

The second species, which corresponds to *Brunia phylicoides* Thunberg, Pillans referred to *Raspalia globosa* based on *Phylica globosa* Lamarck (1797). If this is in fact a *Raspalia*, it is clearly the earliest epithet available but the illustration is so equivocal, showing no flowers at all and no indication of scale, that it might be either of the two species discussed and only examination of the type material can clarify the matter. In the interim the robust species should continue to be referred to as *Raspalia globosa* (Lamarck) Pillans, and the slender species as *Raspalia passerinoides* (Schlechtendal) Presl.

### ***Tittmannia laxa* (Thunberg) Presl**

Holotype: Thunberg 5743. "*Brunia laxa*."

*Tittmannia* is a conserved genus, the type species given in the Nomina Generica Conservanda being *Tittmannia laterifolia* Brogniart (1826). This is apparently an orthographic error for *Tittmannia lateriflora* which is the only *Tittmannia* Brogniart described. Brogniart's excellent drawings show this to be undoubtedly conspecific with *Brunia laxa* Thunberg (1800). This state of affairs is similar to that in the conserved genus *Lonchostoma* where the type species is cited as *Lonchostoma obtusiflorum* Wikström nom. illeg. [*Passerina pentandra* Thunberg, L. pentandrum (Thunberg) Druce].

Pillans (1947) proposed a new large-flowered variety of *Tittmannia laxa*, var. *langebergensis* from Montague. He regarded the typical variety of *Tittmannia laxa* as being the small-flowered form which is fairly widespread through the Cedarberg, Witzenberg and Koubokkeveld to Matroosberg and Keeromsberg near Worcester, with outlying records from Piquetberg, Drakenstein Mountains

and Jonkershoek. It is not common, existing as isolated populations on the various mountains and exhibiting a fairly wide range of variation particularly in the leaves which vary in size and shape and are sometimes even moderately hairy.

Pillans regarded this variable small-flowered form as conspecific with the two species described by Dümmer (1912) *Tittmannia oliveri* and *Tittmannia pruinosa*. These two are undoubtedly conspecific, *Tittmannia pruinosa* (Bodkin 1153 isotype BOL) being a fruiting specimen of *Tittmannia oliveri* (Schlechter

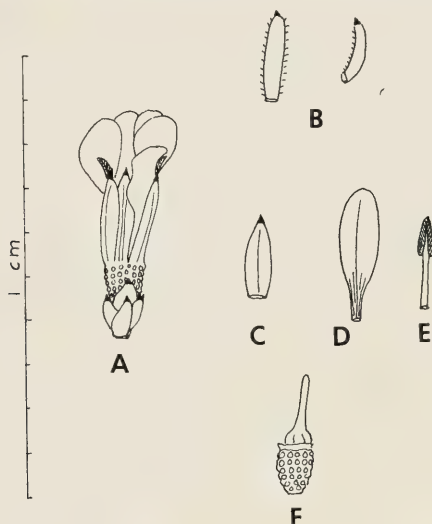


FIG. 7.

"*Brunia laxa*" Thunberg 5743.

A: flower. B: leaf, adaxial and side view. C: sepal. D: petal. E: stamen. F: ovary.

8874, isotype BOL) and were described simultaneously. Unfortunately Thunberg's type does not match this small-flowered form but matches the large-flowered form from Montague, so that var. *langebergensis* Pillans is a superfluous name.

It would obviously be preferable to regard the local form from Montague as a geographical subspecies of the more widespread small-flowered form, but since this is not compatible with the International Code of Nomenclature, the small-flowered form must be treated as a subspecies and must be typified by one of the species already described. The name proposed is *Tittmannia laxa*

(Thunberg) Presl subsp. *oliveri* (Dümmer) Powrie, comb. nov. et stat. nov.: basionym *Tittmannia oliveri* Dümmer in Journal of Botany **50**: supp. 2: 16 (1912).

This subspecies differs from the typical subsp. *laxa* in having flowers less than 4 mm long, while subsp. *laxa* has flowers 5 mm long or more.

**Lonchostoma pentandrum** (Thunberg) Druce

Holotype: *Thunberg* 6339. "Lonchostoma obtusiflora" overwritten on "Passerina—" (the second word is illegible), also labelled "Gnidia pentandra".

Here Druce's combination (1916) antedates Pillans (1947), and though based on *Gnidia pentandra*, not the earlier *Passerina pentandra*, it must stand (Article 33, Note 2, International Code of Nomenclature 1966). There is a fragment in the Herb. Retzius labelled "Lonchostoma obtusiflora ex Thunberg" and "Passerina pentandra" deleted, which is probably a portion of the type.

**Brunia laevis** Thunberg

Holotype: *Thunberg* 5740. "Brunia laevis."

This is a small fragment but the leaves of this species alone are quite characteristic.

**Brunia alopecuroides** Thunberg

Holotype: *Thunberg* 5734. "Brunia alopecuroides."

This consists of a small portion of one of the upper branches with a few inflorescences and the modified leaves adjoining them. The small, laterally arranged inflorescences are suggestive of *Berzelia* but bear the characteristic two-styled flowers of *Brunia*. Sonder found only one style in this species but must have examined abnormal material for the type clearly has two.

**Raspalia microphylla** (Thunberg) Brogniart

Holotype: *Thunberg* 5744. "Brunia microphylla."

Brogniart wrongly interpreted the floral morphology in this species since, as in all *Raspalias*, the calyx readily strips off carrying part of the receptacle with it, thus leading him to describe the calyx as "free and inferior", an error pointed out by Arnott. Despite this there is no difficulty in relating Brogniart's excellent illustrations to Thunberg's type.

In conclusion I wish to thank the Director of the Herbarium of the Institute of Systematic Botany, University of Uppsala, for the loan of the Thunberg material; the Director of the National Herbarium of Victoria for the loan of Sonder's material; the Botanical Museum at the University of Lund for the loan of material from the Herb. Retzius and for copies of papers by Thunberg, Swartz, Dahl, Vahl and Wikström with translations from the Danish and

Swedish. I also wish to thank Professor Schelpe for permission to work in the Bolus Herbarium, for arranging the various loans and in preparation of this article. All material cited other than in the Thunberg and Sonder collections is in the Bolus Herbarium.

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## BOOK REVIEW

PLANT CELLS by F. A. L. Clowes and B. E. Juniper. Botanical Monographs, Volume 8, xvii + 546 pages with 163 figures. Oxford and Edinburgh: Blackwell Scientific Publications, 1968. Price £6.

The past ten years have been momentous ones for the student of cell structure. During this period, due largely to improvements in methods of tissue preparation, a consolidated and reproducible picture of the sub-microscopic structure of the cell has developed. *Plant Cells* is a timely and concise summary of the current state of knowledge in particular aspects of this field. The authors admit that the selection and treatment of topics was motivated by personal interests, which has inevitably led to some imbalance, but nevertheless they have succeeded in producing a very readable condensation of the vast literature which now helps to span the gap between microscopic and molecular morphology. Over seven hundred literature references are cited, most of which were published within the last ten years and a hundred and forty-three since 1965, which provide a very adequate guide to the reader in need of more detailed information.

The first two chapters give a brief introduction to techniques and to certain problems of cell size and shape. There follows an account of the ultra-structure of cytoplasm and a survey of cytoplasmic organelles. Wall structure is treated in some detail in Chapter 4, although much of what appears here has been adequately covered by other authors. The chapter on the nucleus does to some extent reflect the inadequacy of present knowledge but it is a pity that the authors of this book have elected not to discuss chromosome morphology, a subject which remains in need of a modern re-appraisal. Chapter 8, on the cell cycle, is an interesting account of this often forgotten aspect of the life of the cell and is obviously based on Dr. Clowes' personal investigations. After a review of some aspects of cell differentiation there follows a most valuable chapter which deals with the structure and development of selected specialised cells and the range of diversity of the organelles within different cell types, a section which might profitably have been expanded further. In the final chapter of the book there is a very useful summary of intercellular information transfer systems, including the inheritance of plastids and mitochondria.

The twenty page glossary is of doubtful value. Is it really anticipated that the class of readers who will use this book will be unfamiliar with the meaning of *auxin*, *chloroplast coleoptile*, *mitosis*, *petiole*, *spore* or *xylem*? The descriptions provided are in any case so superficial that they will hardly enlighten. The index is also inflated by trivialities. For example *oxygen* is given seven page references of unspecified association. The sentence (p. 214) "*They (tannins) account for the bitter taste of some fruits, tea and beer*" merits separate entries for *tea* and *beer* although surprisingly, there is no corresponding reference under *fruit*!

As we have come to expect from Blackwell's Scientific Publications, the layout and production of this book is of a high quality. The half tone and line illustrations are excellent and the type is clear and attractive. However, at £6 it seems probable that this book will be purchased mainly by libraries. One is tempted to ask whether, in a field developing as rapidly as sub-microscopic morphology and in which a general work of this nature may have a life expectancy of five years, such a lavish production is justified.

Despite these criticisms this is a most useful and stimulating book. It can be recommended unreservedly to third years and honours botany students as well as to more advanced workers who require an introduction to current ideas in plant cell research.

A. R. A. NOEL



## THE GENUS *PORPHYRA* ON SOUTH AFRICAN COASTS:

### ERRATUM

Journal of South African Botany, 35, 2, 1969.

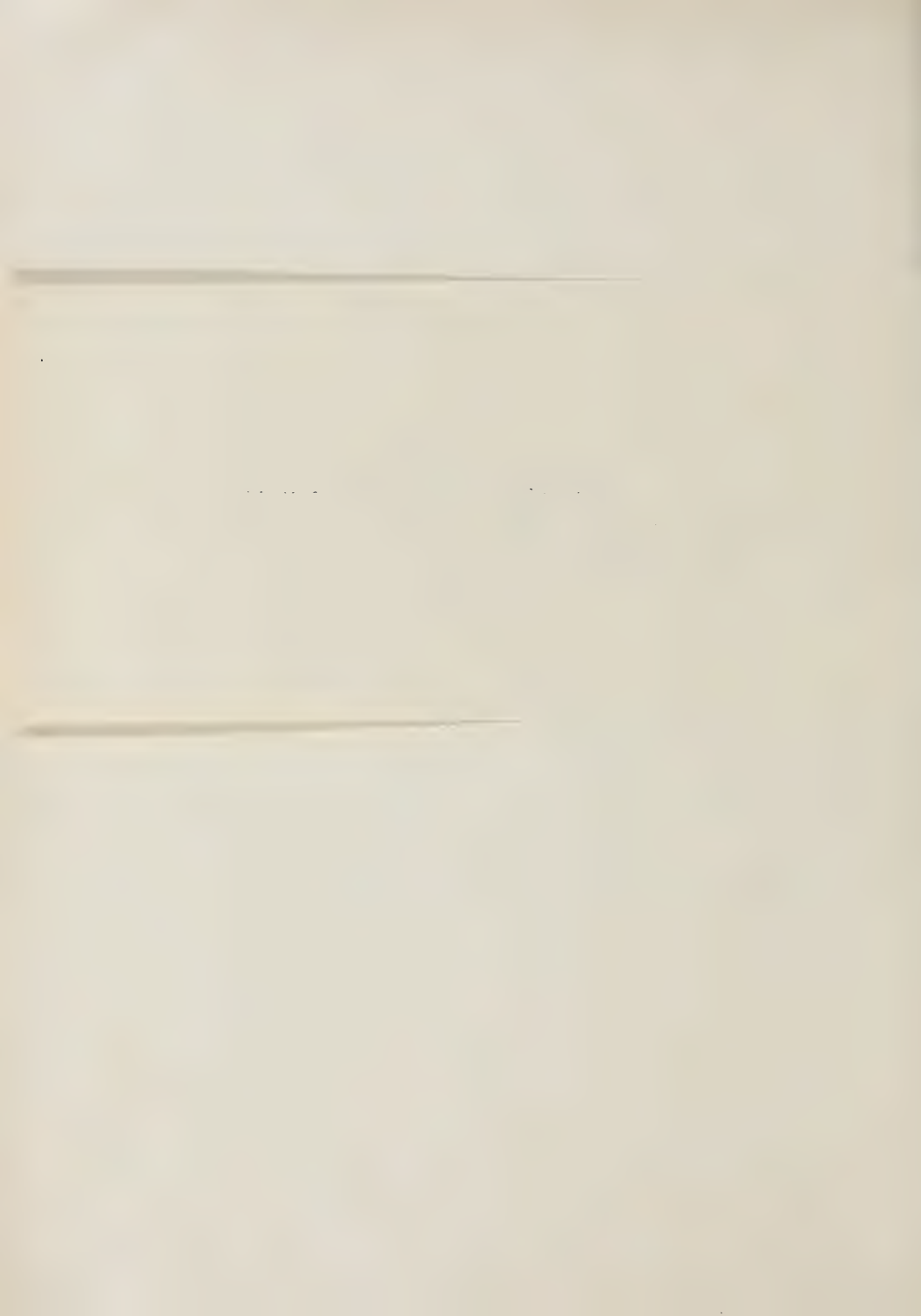
In title of paper, pp. 113-126:  
*for Annular read Annual.*

attention over a number of years (Drew 1954, Tseng and Chang 1955, Graves 1955, Krishnamurthy 1959, Miura 1961, Conway 1964) and it is perhaps surprising that no consistent pattern of biology applicable to the genus as a whole has yet emerged. The occurrence of a microscopic filamentous phase, the *conchocelis*-phase, is well known. There have also been reports of "dwarf plants" (Tseng and Chang 1955) or "plantlets" (Drew 1954, Conway 1964, 1966) usually described as having the same form as the familiar leafy parenchymatous thallus but considerably smaller and reproducing by means of monospores only. The significance of these phases as regards the life cycle of *Porphyra* remains obscure, however, partly because of a lack of agreement in the accounts as to the method of formation and fate of the reproductive bodies produced by the full-sized parenchymatous plant.

While the present paper does not attempt to solve these basic problems, it is hoped that it will be of value in presenting a more complete picture of the biology of *Porphyra capensis* than is at present available. For the purpose of this paper the name *P. capensis* is used in the sense in which it is used by Isaac (1957). Further reference to the taxonomic position is made in the discussion.

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Accepted for publication 20th June, 1969.



## THE GENUS *PORPHYRA* ON SOUTH AFRICAN COASTS:

### I. OBSERVATIONS ON THE AUTECOLOGY OF *PORPHYRA* *CAPENSIS* SENSU ISAAC (1957), INCLUDING A DESCRIPTION OF DWARF PLANTS.

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#### ABSTRACT

The various forms of *Porphyra capensis* are described and discussed from the points of view of external morphology, vegetative cell structure and arrangement of reproductive bodies. Developmental changes are shown to occur in vegetative cell structure. It is possible that the pattern of development is influenced by environmental factors. Both dioecious and monoecious plants occur, but variations in spore arrangement are not consistently related to any other morphological or anatomical features. There is no definite evidence of sexuality in carpospore formation.

The occurrence of dwarf plants, reproducing by means of monospores, is recorded and their possible relation to normal-sized plants of *P. capensis* is discussed.

#### INTRODUCTION

The autecology and life history of several species of *Porphyra* have received attention over a number of years (Drew 1954, Tseng and Chang 1955, Graves 1955, Krishnamurthy 1959, Miura 1961, Conway 1964) and it is perhaps surprising that no consistent pattern of biology applicable to the genus as a whole has yet emerged. The occurrence of a microscopic filamentous phase, the *conchocelis*-phase, is well known. There have also been reports of "dwarf plants" (Tseng and Chang 1955) or "plantlets" (Drew 1954, Conway 1964, 1966) usually described as having the same form as the familiar leafy parenchymatous thallus but considerably smaller and reproducing by means of monospores only. The significance of these phases as regards the life cycle of *Porphyra* remains obscure, however, partly because of a lack of agreement in the accounts as to the method of formation and fate of the reproductive bodies produced by the full-sized parenchymatous plant.

While the present paper does not attempt to solve these basic problems, it is hoped that it will be of value in presenting a more complete picture of the biology of *Porphyra capensis* than is at present available. For the purpose of this paper the name *P. capensis* is used in the sense in which it is used by Isaac (1957). Further reference to the taxonomic position is made in the discussion.

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## OBSERVATIONS ON FULL-SIZED PLANTS

## 1. Range of form.

The recorded distribution of *Porphyra capensis* is shown in Fig. 1. For details of its distribution the reader is referred to the account by Isaac (1957), but it is sufficient here to say that maximum development, in terms of both number of plants and size of individuals, occurs in the relatively cold waters of the west coast and that there is a general decline in luxuriance as one passes from west to east.

As Isaac points out, three main growth forms are found. The commonest form on the west coast has a large cordate to reniform thallus, dark olive-green or dull purple in colour and cartilaginous in texture (Plate I (a)). Plants of this kind are characteristically perennial, growing between about mid-tide level and high water level of neap tides, although isolated plants may be found down to the sublittoral fringe. These low level plants are usually epiphytic, often on *Aeodes orbitosa* and occasionally on the kelp *Ecklonia maxima*. In exposed situations, where wave action results in some splash, considerable numbers of plants may grow above the normal upper limit. These plants are always smaller and paler in colour than those at lower levels (Plate I (b)). High level individuals do not survive for any length of time but are replaced repeatedly by crops of young plants which are usually brown in colour and very variable in form (Plate II (a)).



FIG. 1.

Map showing the recorded distribution range (cross-hatched) of *Porphyra capensis*. Localities for dwarf plants are ringed.

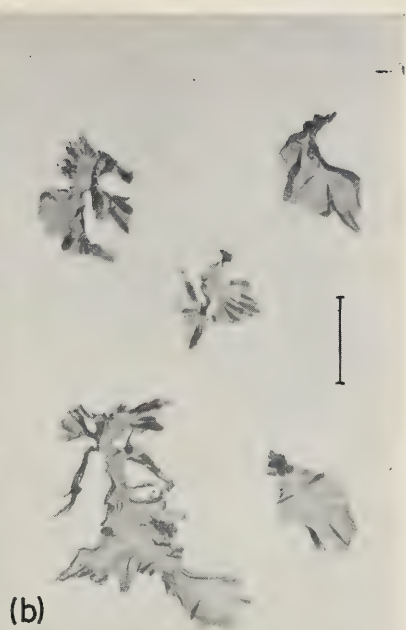
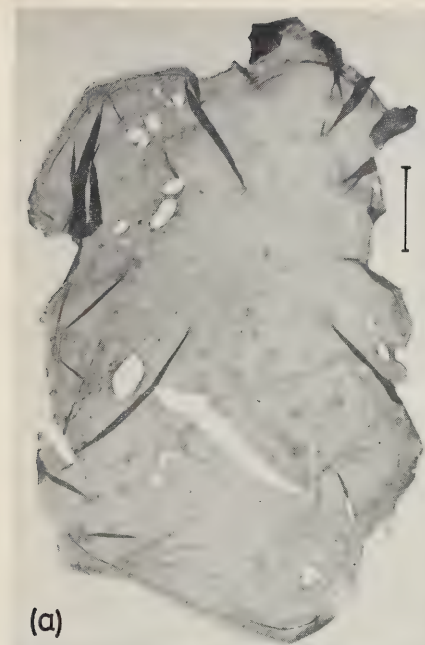


PLATE I.

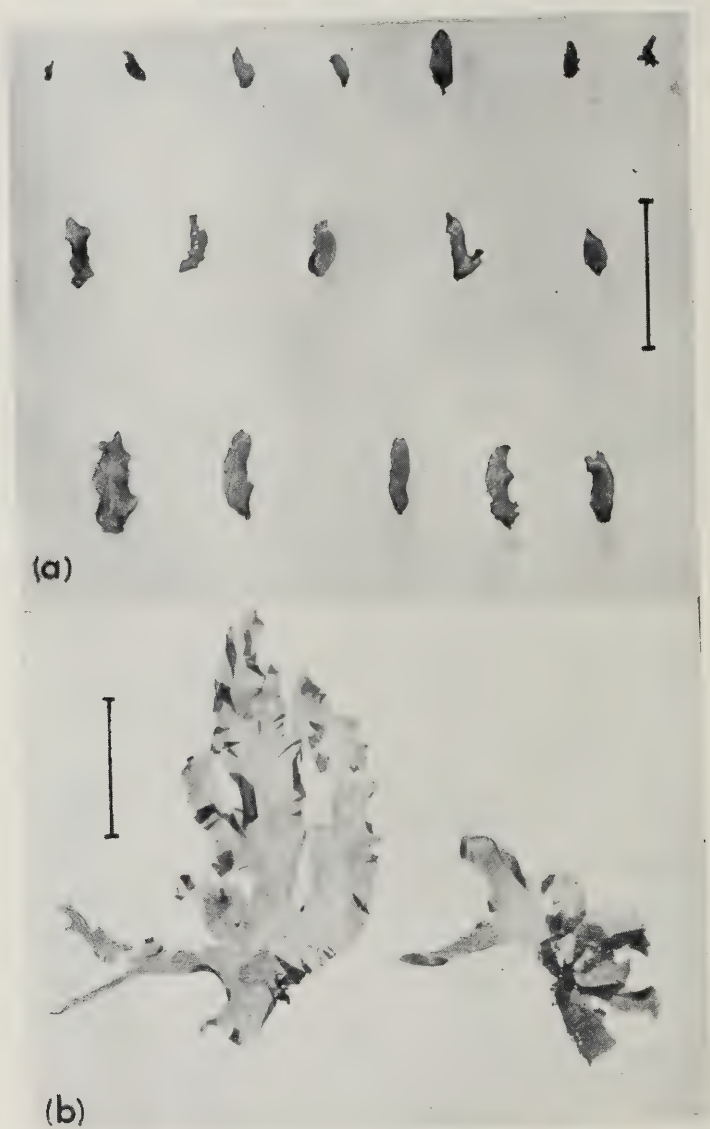


PLATE II.

The second form is characteristic of the relatively warm waters of False Bay and of the south and east coasts. It is basically similar to the high level type described above, although the thallus texture of the warm water form is usually more delicate. Due probably to the fact that the thin thallus is easily torn, these plants are often deeply laciniate (Plate II (b)).

The third form is found in sheltered situations. In the absence of much wave action young plants tend to elongate rapidly, the thallus broadening only slightly as it matures, so that it eventually acquires a linear to lanceolate form (Plate I (c) and (d)). In certain localities on the west coast large numbers of these elongated, ribbon-like plants occur. Many are ephemeral, developing rapidly during the winter or spring and dying off again in the summer months, although they do not necessarily appear as regular annuals.

## 2. Vegetative structure.

The thallus is always monostromatic. In very young plants of all forms the cells as seen in transverse section of the thallus are oval to rectangular, slightly longer than broad, each with a single, axile, stellate chromatophore which is usually brownish red in colour and has a prominent central pyrenoid (Fig. 2.A.). As growth proceeds the cells tend to elongate in a plane at right angles to the surface, the total thickness of the thallus increasing correspondingly. The chromatophore also becomes stretched longitudinally.

It appears that under optimal conditions of growth the elongation of the cells is very marked, takes place rapidly and is accompanied at an early stage by division of the chromatophore so that each cell of the mature thallus has two chromatophores. In typical west coast plants the cells may already have two chromatophores by the time the young plant is 1 cm in length. At first the

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### PLATES I AND II.

Various growth forms of the normal-sized parenchymatous phase of *Porphyra capensis*. Scale line represents 5 cm. in all cases.

#### PLATE I.

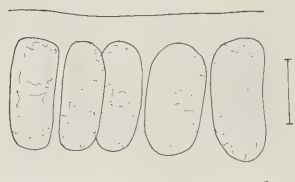
- (a) Cartilaginous reniform "male" plant. Bakoven, west coast of Cape Peninsula, February 1967.
- (b) Typical plants from high water of neap tides level. Granger Bay, Cape Town. March 1967.
- (c) "Male" (left) and carposporic plants of the linear, dioecious form. Llandudno, west coast of Cape Peninsula. September 1966.
- (d) Monoecious plant. Carposporic areas are visible as dark patches on the paler background of the spermatial areas. Melkbosch Strand, 12 miles north of Cape Town. March 1967.

#### PLATE II.

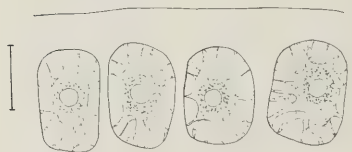
- (a) Young plants. Melkbosch Strand, March 1967.
- (b) "Male" (the smaller) and carposporic plants of the delicate, laciniate form. St. James, False Bay, May 1952.



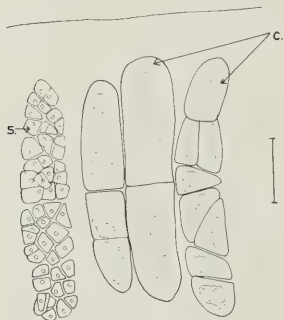
A.



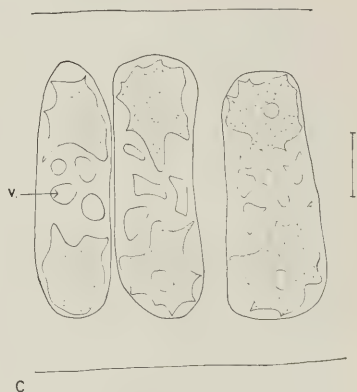
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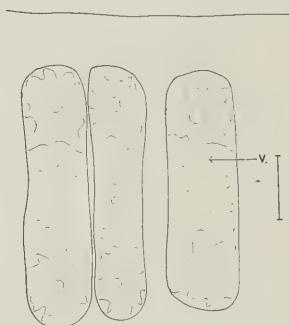
D.



F.



C.



E.



G.



two chromatophores retain the marked stellate form characteristic of the very young plant and are close together, so that they practically fill the protoplast of the cell. Vegetative cells frequently have this appearance in plants just starting to produce spores (Fig. 2.B.). As elongation of the cells continues, the chromatophores move one to each end of the cell. Numerous vacuoles are usually present in the central area of colourless cytoplasm. The chromatophores eventually lose the narrow extensions which give them a stellate form in the young cells and become lobed. Their colour also changes from brown to dark green and the pyrenoids become less distinct (Fig. 2.C. and E.). The total thickness of the thallus of the mature plant is very variable but is usually between 90 and 125 $\mu$ . At this stage the thallus has acquired its characteristic cartilaginous texture.

A few plants having the mature structure just described may be found in regions of relatively warm water, for example in False Bay. However, the delicate texture typical of the vast majority of warm water plants is associated with the fact that the cells retain the juvenile form. In these the vegetative cells elongate only slightly, most retaining the single chromatophore and the total thickness of the mature thallus does not usually exceed 65 $\mu$  (Fig. 2.D).

### 3. Reproduction and spore types.

In common with other species of *Porphyra*, *P. capensis* produces large numbers of two distinct types of spore. These are the deeply pigmented bodies commonly known as carpospores and the much smaller, colourless spermatia. In addition relatively small numbers of a third type of spore-like body may be released from certain thalli. For convenience these may be termed accessory spores.

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FIG. 2.

A. T/S living thallus of a very young plant of *P. capensis* showing single stellate chromatophore with central pyrenoid in each cell. Material from Three Anchor Bay, Cape Town. March 1967.

B. C. D. and E. T/S living thalli of four mature (i.e. fertile) plants of *P. capensis* showing vegetative cells, v = vacuoles.

B. Lanceolate form from Bakoven, west coast of Cape Peninsula. February 1967.

C. Lanceolate form from Melkbosch Strand, approximately 12 miles north of Cape Town. March 1967.

D. Delicate, lacinate form from St. James, False Bay. April, 1967.

E. Reniform plant from Bakoven. February, 1967.

F. T/S fertile thallus margin of monoecious plant of the "sector" type, the section taken across the dividing line between spermatial and carposporic sectors. s = spermatium. c = dividing carpospore mother cells. Melkbosch Strand. March, 1967.

G. T/S fertile thallus of carposporic plant, showing remains of trichogyne-like extensions of the mother cells and corresponding humps of surface matrix. Kommetjie, west coast of Cape Peninsula, April, 1955. Scale line represents 20 $\mu$  in all cases.

The original accounts of the species (Kützing 1849, Agardh 1883) do not distinguish the various spore types nor do they indicate whether the plants are monoecious or dioecious. *P. capensis* has generally been regarded, however, as typically dioecious, or, if monoecious, then of a rather peculiar type in which the carpospores and spermatia are produced in different sectors of the thallus, separated by a sharp line of demarcation (Isaac 1957, Fig. 2). For the majority of plants throughout the geographical range this description is accurate. Carposporic plants (or sectors of plants) are characterised by a deep red or pink margin, while those producing spermatia have a yellow or cream margin (Plate I (c)). The paler colour in each case is associated with a thinner thallus. The ephemeral linear or lanceolate form is very prolific in spore production and this has a marked effect on the colour of the mature thallus, particularly in the case of the carposporic plants, in which almost the entire thallus becomes deep red.

On the west coast some monoecious individuals occur, particularly at low levels, in which packets of carpospores and spermatia are borne in irregular intermingled patches. Such plants are usually ephemeral, roughly 10% of the individuals in populations of the linear to lanceolate form being of this type. In terms of morphology and vegetative structure they are indistinguishable from dioecious plants (Plate I (d)). Monoecious plants of this type have not so far been found in False Bay or further east.

The terms "carpospore" and "spermatium" are used here for convenience only, since there is no convincing evidence that any sexual process is involved in reproduction in *P. capensis*. This is in keeping with the findings of workers who have investigated northern European species (Krishnamurthy 1959, Conway 1964). Occasionally carposporic plants are found in which the cells near the thallus margin have elongated extensions of the protoplast at one or both ends, similar in appearance to the trichogynes which have been figured for *P. tenera* (Kunieda in Fritsch 1945, vol. II, p. 432, fig. 144 J; Tseng and Chang 1955a). These extensions may be very pronounced, the surface matrix being raised above them in a series of humps (Fig. 2.G). However, this phenomenon is by no means common and furthermore no spermatia have been found in any way associated with the trichogyne-like structures.

No change in the thickness of the thallus accompanies spore formation. Typical cold water plants, in which the vegetative cells are elongated and have two chromatophores, develop correspondingly elongated spore packets, approximately 128 spermatia or 32 carpospores being formed per mother cell. The form of the spore packets and approximate number of spores is the same whether the plant is dioecious or monoecious of either type. The first division of the mother cell is usually transverse in the formation of both carpospores and spermatia (Fig. 2.F). Mature carpospores in general lie in 8 tiers of 4 spores each and mature spermatia in 16 tiers of 8 each. However, neither the number nor the

arrangement of the spores is constant and many of the divisions may be oblique (Figs. 2.G and 3.A).

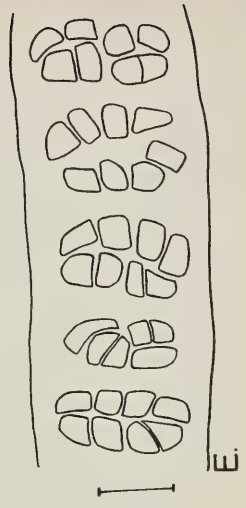
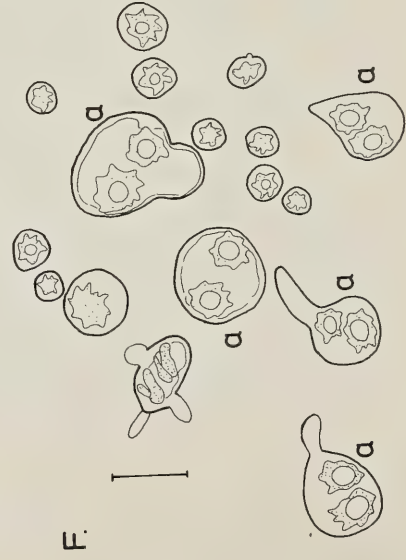
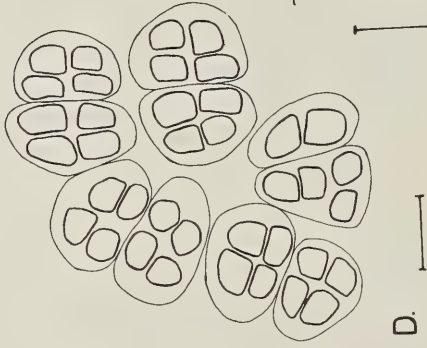
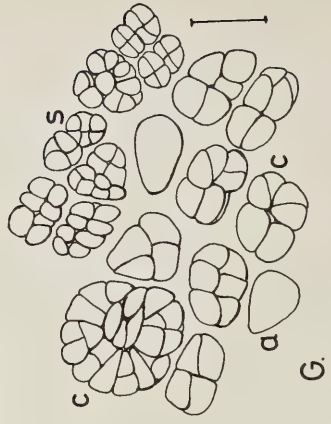
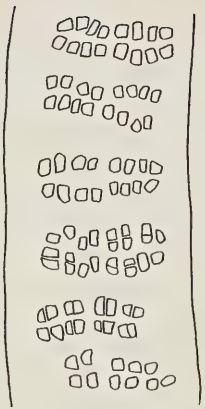
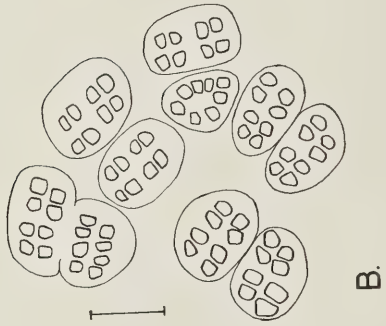
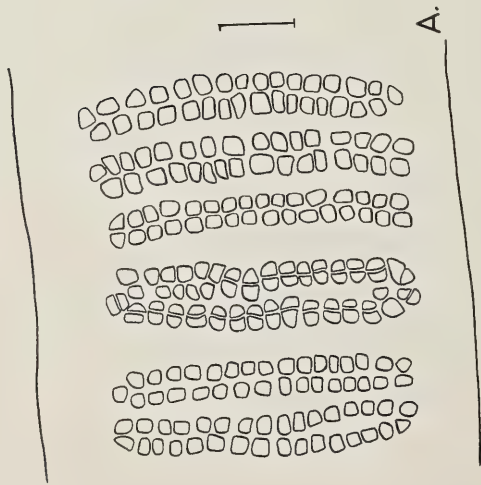
In plants in which the vegetative cells are only slightly elongated, the number of spores formed from each mother cell is approximately half the number typical of cold water plants; that is to say, 16 carpospores in 4 tiers of 4 spores each and 64 spermatia in 8 tiers of 8 spores each (Fig. 3.B, C, D and E).

In the case of the "male" thallus every cell in the fertile region divides to form spermatia. In some carposporic thalli (or the carposporic areas of monoecious plants) division of the cells in the fertile region appears to be in some way inhibited. Many cells fail to divide at all and remain greenish in colour while others divide irregularly so that the number of carpospores formed per mother cell is very variable (Fig. 3.G).

In such cases the first division of the mother cell is often longitudinal instead of transverse, one daughter cell remaining undivided while the other forms carpospores. If undivided cells are in the majority, the fertile margin of the plant appears pale greenish brown in colour with a number of red streaks indicating the presence of developing carpospores. The appearance is very similar to that figured by Smith (1944 plate 38, Fig. 2) for *P. lanceolata* (Setchell and Hus) G. M. Smith, and described by him (p. 170) as "packets of carpospores in hieroglyphic-like lines".

Undivided cells, including those daughter cells of potential carpospore mother cells which fail to divide further, may be released as spore-like bodies which may be termed accessory spores. The term "monospore" is not applicable since cell division may precede spore formation. Once released the accessory spores may be distinguished from carpospores by their greenish colour and larger size (20—35 $\mu$ ), although the latter is not always a reliable guide since the carpospores are very variable in size. Accessory spores produced by typical cold water plants are often recognizable because of the presence of two chromatophores in each spore in contrast to the single one characteristic of the carpospore (Fig. 3.F). As yet attempts to induce accessory spores to germinate under culture conditions have been unsuccessful. In a few cases germ tubes have been formed as shown in Fig. 3.F, but growth has not proceeded further and it is not even possible to say whether sporelings are likely to be filamentous growths or parenchymatous thalli.

The carpospores without exception each have a single red or deep pink chromatophore. At the time of shedding there is a wide variation in size (10·0 $\mu$ —20·3 $\mu$ ), even amongst spores shed by a single thallus. After they are released the spores enlarge considerably and numerous vacuoles appear in the cytoplasm. For some time before germination they undergo amoeboid changes of shape.





Germination takes place readily in culture and filamentous growths are formed which develop into a typical *conchocelis*-phase (Graves 1955; see also Plate IV) similar in all essentials to those which have been described for other species (Drew 1954, Tseng and Chang 1955).

#### THE DWARF PLANTS

##### 1. Field Observations.

This account is based on the following collections examined: CAPE PROVINCE, East London, 17.ix.1955, *Graves P.59*. East London 18.vii.1965, *Graves P.60*. Port St. Johns (First Beach) 10.vii.1959, *Isaac*. Beach on the farm Brandfontein (approximately 10 miles west of Cape Agulhas) 8.xii.1964, *Graves*. NATAL. Salt Rock Beach (hotel rocks) 26.ix.1953, *Isaac*. These localities are also indicated in Fig. 1.

The plants in all three collections made by the author were growing at a level approximately midway between high water level of neap tides and low water level of neap tides, that is to say in a position typical for *Porphyra capensis*. No information as to level was available with the material collected by Isaac. However, the plants from Port St. Johns were attached to shells of the barnacle *Chthamalus dentatus* which indicates an upper midlittoral position.

At the Brandfontein farm locality large numbers of full-sized *P. capensis* plants were also present, growing in close proximity to the dwarf ones. At East London no full-sized plants were found on either occasion. The species is never common in this eastern part of its range (Isaac 1957). It will be noted that Port St. Johns represents the eastern limit of the recorded distribution of *P. capensis*, while the Salt Rock Beach locality is well beyond the range of full-sized *Porphyra* plants.

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FIG. 3.

- A. T/S fertile thallus margin of "male" plant of *P. capensis* showing 16 tiers of spermatia in each spore packet. Kommetjie. April, 1955.
- B. Surface view and
- C. T/S of fertile thallus margin of "male" plant, showing packets of spermatia made up of 8 tiers of 8 spores each.
- D. Surface view and
- E. T/S of fertile thallus margin of carposporic plant, showing packets of carpospores made up of 4 tiers of 4 spores each. Both plants from Port St. Johns. January, 1939.
- F. and G. Spore types in *P. capensis*.
- F. Carpospores and germinating accessory spores (a) from a carposporic plant collected at Bakoven, June, 1965. Drawn from living material.
- G. Surface view of fertile thallus margin of monoecious plant showing spermatia (s), carpospore packets containing variable numbers of carpospores (c), and undivided cells (a). Llandudno, west coast of Cape Peninsula. December, 1966. Scale line represents 20 $\mu$  in all cases.



Dwarf plants are easily distinguishable in the field by their bright rose-red colour and, when fertile, by the delicate pink margin caused by the production of large numbers of monospores. Ordinary juvenile plants of *P. capensis*, as already stated, are brownish in colour and they never produce spores. Also the dwarf thalli are uniformly shaped (cordate to reniform) and tend to be crowded together in small isolated patches rather than distributed over a wide area.

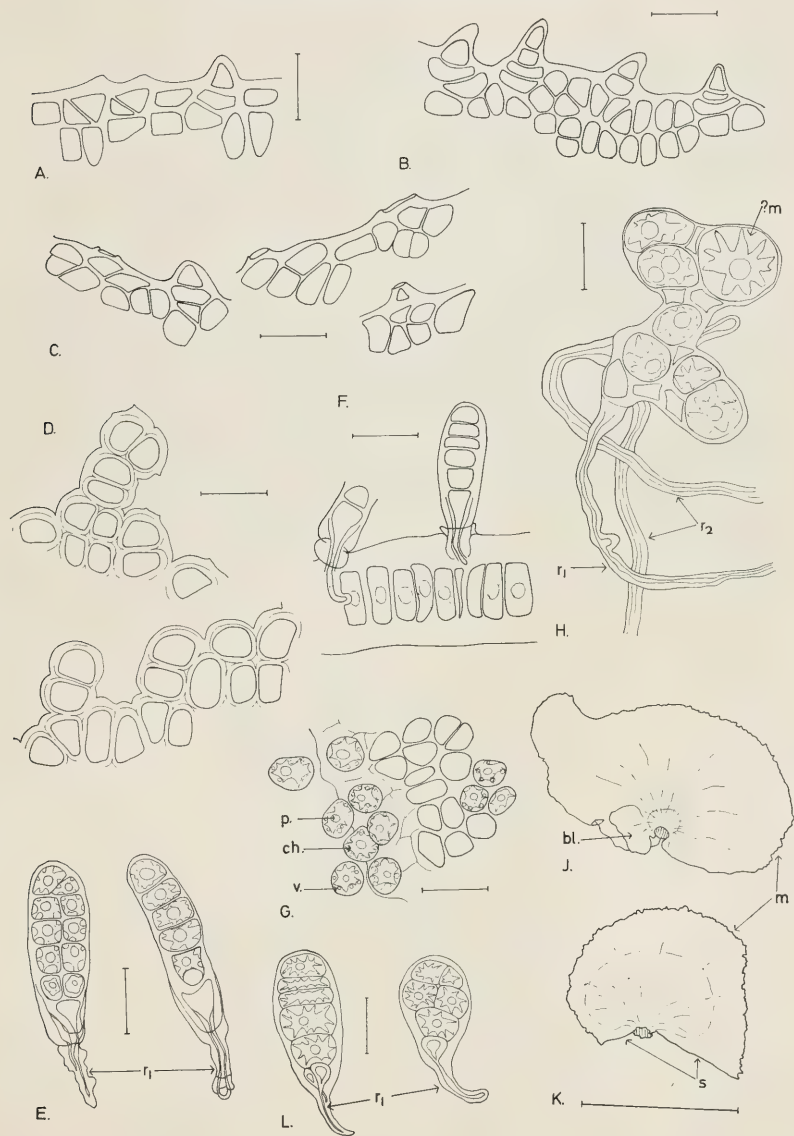
## 2. Morphology, structure and spore production.

The very young dwarf plants are identical in colour and form to the plants formed at the germination of the conchospore of the *conchocelis*-phase of *P. capensis* (cf. Fig. 4 E and L).

Up to six cells are formed at first in a uniseriate row, the basal cell distinct and producing a thick-walled, colourless, primary rhizoid. At this stage longitudinal divisions begin and become more frequent so that the thallus broadens first to a lanceolate and then to a cordate form. At this stage the thallus is from 1.0 to 2.0 mm long and about the same breadth at the broadest part. Secondary rhizoids from the basal cells form a small, disc-like holdfast. In section the cells are very similar to those of ordinary juvenile plants of *P. capensis* except that they are much smaller and the single, stellate chromatophore

FIG. 4.

- A, B and C. Serrated thallus margins of dwarf plants.  
 A. Early stage in the development of serrations, showing oblique divisions of marginal cells. Port St. Johns material.  
 B. Part of the serrated thallus margin of a sporulating dwarf plant. Brandfontein material.  
 C. Thallus margin of a mature dwarf plant showing erosion of serrations. Graves P. 60 material.  
 D. Parts of the fertile thallus margin of the plant shown in K, showing large, rounded potential monospores. Drawing made from preserved material in which there has been some shrinkage of the protoplasts.  
 E. Two of many young plants found attached to dwarf plants at the Brandfontein farm locality, December, 1964.  $r_1$  = primary rhizoids.  
 F. T/S thallus of a dwarf plant passing through the bases of two epiphytic young plants like those shown in E. The primary rhizoids of the epiphytes may be seen penetrating the matrix and growing towards the "host" cells. Graves P. 60 material.  
 Drawn from preserved material; protoplasts stippled.  
 G. Part of the fertile thallus margin of a living dwarf plant showing release of monospores. Brandfontein material. ch = chromatophore. p = pyrenoid. v = vacuole.  
 H. Young plant formed in culture as a result of germination of a monospore from a dwarf plant. Spores obtained from Brandfontein material. Culture 27 days old.  $r_1$  = primary rhizoid.  $r_2$  = secondary rhizoid. ? m = ? potential monospore.  
 J. and K. Morphology of dwarf plants. Holdfasts are crossed-hatched.  
 J. Plant from Graves P. 59 material, showing small secondary blade (bl.). Fertile region of thallus margin (m) not sharply demarcated from sterile region, which in this case is smooth.  
 K. Plant from Salt Rock Beach material, showing abrupt demarcation between the fertile region of the thallus margin (m) and the sterile, serrated region (s).  
 L. Young plants of the parenchymatous phase of *P. capensis* formed as a result of the germination of conchospores. Drawing made from living material taken from a 9 month old culture of the *conchocelis*-phase.  $r_1$  = primary rhizoids. In J. and K. scale line represents  $\frac{1}{8}$  in., in all others 20 $\mu$ .



in each cell is deep rose red in colour. The total thickness of the thallus is variable, but in general it is less than that of the ordinary juvenile plant. In the material examined the height of the cells varied between  $13.7$  and  $21.2\mu$ . The total thickness of the thallus was from  $25.0$  to  $36.2\mu$ .

In general the margins of the young plants become distinctly serrated (Fig. 4. B.). The development of a serration may be seen at first as an oblique division of one of the marginal cells, accompanied by a slight protuberance of the surface gelatinous matrix (Fig. 4. A.). The serrations are usually evenly distributed around the margin, but may be developed on one side of the thallus only.

As the thallus broadens the attachment becomes distinctly umbilicate in most cases. The blade remains entire and usually there is only one blade per holdfast, although the plants may be so crowded together that several appear to arise from a single base. Occasionally very small secondary blades do proliferate from the holdfast (Fig. 4. J.).

The mature thallus is in most cases broadly reniform but the shape may be considerably modified by spore production. This begins and is most vigorous along the upper edge furthest from the holdfast, but spreads gradually around the margins. There is usually an abrupt demarcation between the sterile serrated margin near the base of the plant and the upper fertile region (Fig. 4. K. and Plate III (a)). A small proportion of plants have smooth margins with no serrations at all. In these spore production appears to take place evenly around almost the entire margin so that the thallus has a rounded appearance as compared with thalli having serrated margins. All the plants of the Graves p. 59 collection were of this type and there were a few amongst the p. 60 material (Fig. 4. J. and Plate III (b)).

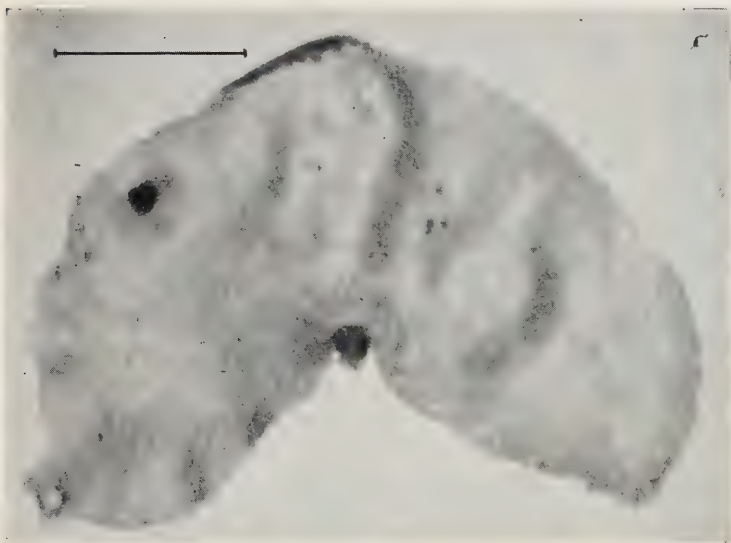
Even if a dwarf plant is not actively sporulating, the fertile margin is recognizable because of its very irregular appearance. The potential spores are larger and more rounded than the ordinary vegetative cells of the thallus and they protrude in irregular groups (Fig. 4. D.). In spore formation the entire contents of a marginal cell rounds off and is released as a single spore, no evidence of cell division immediately preceding spore formation having been found at all (Fig. 4. G.). It therefore seems reasonable to apply the term "monospore" to these structures. During spore production every cell in the fertile region produces a spore so that a large number of empty cell walls remain, visible to the naked eye as a pale pink or almost colourless margin to the thallus.

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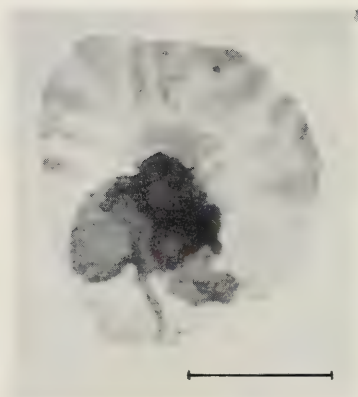
PLATE III.

Dwarf *Porphyras* from East London, July 1965 (Graves P. 60). Scale line represents 1 mm in both cases.

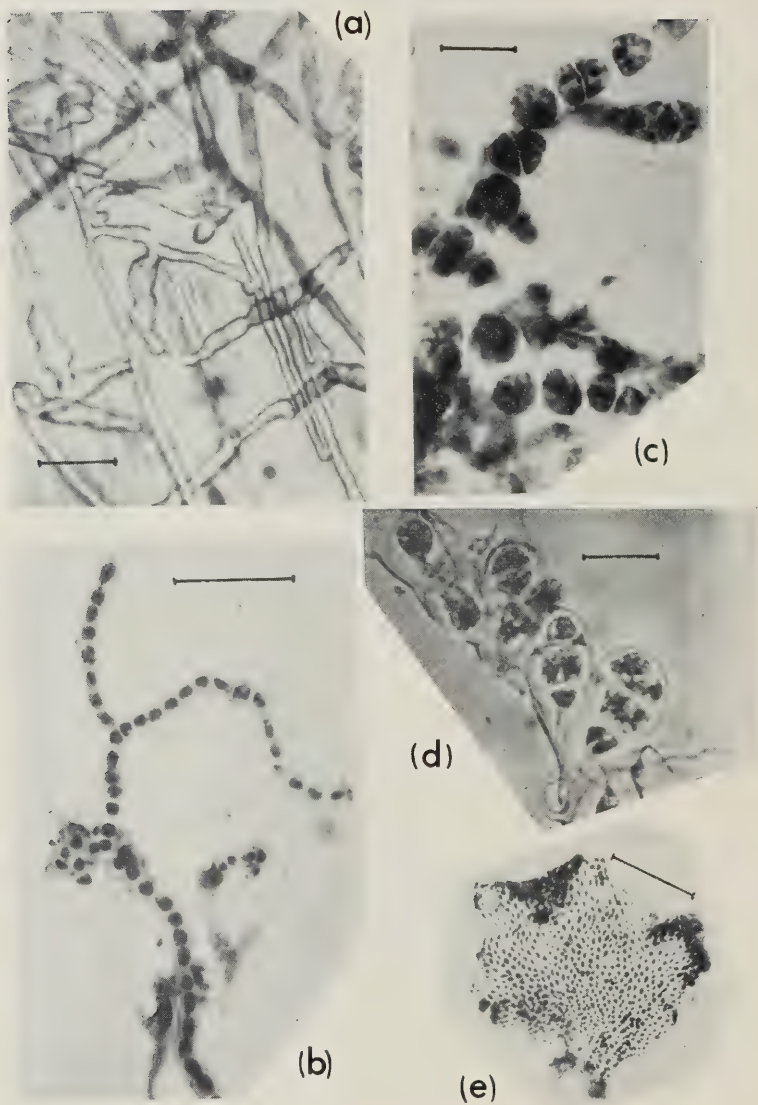
- (a) Reniform plant showing irregular fertile margin sharply demarcated from the sterile margin on either side of the prominent holdfast.  
(b) Umbilicate, rounded plant sporulating around the entire margin.



(a)



(b)





Monospores are very similar in appearance to carpospores and conchospores and are of the same order of size, being from 10–14 $\mu$  in diameter. The single stellate chromatophore in each monospore is deeper in colour and has a more prominent pyrenoid than is the case with the other spore types, however. Numerous vacuoles are usually visible in the colourless cytoplasm surrounding the chromatophore and, like carpospores, monospores exhibit amoeboid changes of shape after their release.

Observations on the germination of monospores were made from the Brandfontein material. Some of the dwarf plants were placed in a petri dish of sterile sea water and the spores shed from them were collected on glass slides. After ten days large numbers of sporelings had developed. In all cases germination was bipolar. The primary rhizoids and later also the secondary ones were abnormally long and the young plants became very irregular in form as compared with those growing under natural conditions (Fig. 4. H.). In some of these thalli one or two of the cells were enlarged (? m in Fig. 4. H.) and similar in appearance to those illustrated as monospores by Conway (1964, plate II, fig. 11, p. 352) in her account of dwarf plantlets of *P. umbilicalis* (L.) J. Ag. In the material under discussion no release of spores was observed, however, and the form of the cells seemed to be merely an expression of the general difformity of the thalli. Similar abnormalities in growth had previously been observed in the development, in culture, of some conchospore sporelings.

In the field monospores are obviously produced in large numbers and germinate rapidly. Most of the mature plants collected at Brandfontein had large numbers of sporelings growing epiphytically on them. In section one could see that the rhizoids penetrated quite deeply into the gelatinous matrix of the "host" plant. They showed an apparent tendency to grow towards the "host" cells which in places had depressions in their protoplasts where the rhizoids had come into contact with them (Fig. 4. F.). There was, however, no definite indication of parasitism.

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PLATE IV.

*Conchocelis*-phase of *P. capensis*. In (a), (c) and (d) the scale line represents 20 $\mu$ .

Others as indicated. With the exception of (a), all from a 9 month old culture.

(a) Early stage in the development of the *conchocelis*-phase, showing fusions between adjacent threads embedded in an oyster shell flake. Culture 25 days old.

(b) A long sporangial branch and some vegetative threads. Scale line represents 100 $\mu$ .

(c) Mature sporangial branches in which the cross walls between the sporangia have mostly broken down to form sporangial tubes containing the conchospores. In some cases the contents of the sporangium have divided to form two spores.

(d) Young plants of the parenchymatous phase formed from conchospores which have germinated while still enclosed within the sporangial tube.

(e) A larger plant of the parenchymatous phase formed as a result of the germination of a conchospore. Scale line represents 0.25 mm.

In size fertile dwarf plants range from 2.0 to 4.0 mm long and from 2.5 to 7.0 mm broad, the largest plants so far seen being from Port St. Johns. Larger plants, 1 cm or more in length, were growing with the dwarf plants at Brandfontein and at East London in 1965, but they differed from typical dwarf plants in a number of respects. The thalli were irregular in form, greenish in colour and had completely smooth, sterile margins with no sign of either monospores or serrations. In other words, they looked like very small, typical *P. capensis* plants. Some of the largest dwarf plants in the East London material showed evidence of the loss of the marginal serrations which appeared to be eroding away (Fig. 4. C.).

#### DISCUSSION

The most striking feature to be revealed as a result of detailed study of the full-sized parenchymatous phase of *P. capensis* is the wide range of variation in morphology, cell structure and arrangement of reproductive bodies which it exhibits. Previous workers (Agardh 1883, Issac 1957) have recognized that thallus form alone is of little value as a taxonomic character in this case. Of greater interest is the range of variation in cell structure and, more particularly, in spore arrangement which affects characters commonly used in the delimitation of species in *Porphyra*.

It has been shown that variations in vegetative cell form and structure are mainly expressions of developmental change, the pattern of development probably being influenced to some extent by environmental conditions. Furthermore, none of the three variations in spore arrangement which have been described is consistently associated with any other feature, either morphological or structural and there is at present no explanation for the occurrence of these variations. It is of interest to note in this connection that variations in spore development and arrangement described by Hus (1902) for *P. perforata* J. Ag. and *P. perforata* f. *lanceolata* Setchell and Hus (*P. lanceolata* (Setchell and Hus) G. M. Smith 1944) bear a striking resemblance to those found in *P. capensis*. Hus separates *P. perforata* f. *lanceolata* from *P. perforata* mainly on the grounds that the form is dioecious while the species is monoecious with irregular alternating patches of carpospores and spermatia. However, in describing f. *lanceolata* Hus states (p. 209) "occasionally forked fronds are met with and in such cases it is not unusual to find one fork bearing antheridia, while the other is strictly sporocarpic. These subdioecious fronds form a connecting link between the form and the species proper".

Whatever the explanation of these phenomena may be, the author is of the opinion that the taxonomic significance of spore arrangement must be regarded as suspect until the whole basis of reproduction in *Porphyra* is more clearly

understood and therefore agrees with Isaac (1957) in recognising a single species of intertidal South African *Porphyra*. Isaac gives the name as *P. capensis* Kütz. emend Agardh, but in the author's opinion, there is some doubt as to whether Agardh (1883) was dealing with a wide enough range of forms to make an amendment to the original name of *P. capensis* Kütz. necessary.

The general morphology, structure and intertidal position of the dwarf plants described strongly suggest that they represent a form of *P. capensis*. While they would appear to be similar in morphology and method of spore production to the dwarf plants of *P. tenera* as described by Tseng and Chang (1955), it is not possible at present to say what part dwarf plants may play in the life cycle of *P. capensis*. The known distribution range of dwarf plants is confined to the south and east coasts of South Africa, where the *P. capensis* association is poorly developed or absent. In this region the range of average annual water temperature is about 17°C to 22°C as compared with 13·0°C to 15·5°C for the west coast (Isaac 1957). There are therefore, indications of a relationship between water temperature and thallus development and behaviour reminiscent of that reported for *P. tenera* by Tseng and Chang. The possibility that dwarf plants of *P. capensis* may, like those of *P. tenera*, continue growth after spore production ceases and develop into full-sized plants, is indicated by the occurrence at Brandfontein and East London of thalli intermediate in type between dwarf and typical full-sized plants.

The dwarf plants of *P. umbilicalis* and *P. purpurea* as described by Conway (1964, 1966) would appear, at first sight, to be rather different in behaviour from those of *P. capensis*. Conway's figures for *P. umbilicalis* (1964 Fig. 15 and Plate II Fig. 11) show the release of spores from thalli which are at a very early stage of development, in one case consisting of only three cells. Dwarf thalli of *P. purpurea* apparently behave in a similar manner. However, since the dwarf plants of both these species are known only from cultures, any comparison of their behaviour with that of the South African material in the field is liable to be of doubtful significance.

The present study of *P. capensis* indicates that environmental factors may profoundly influence the morphology, anatomy and reproduction of this species. Conway (1966), in drawing attention to the highly flexible behaviour of the spores of *P. umbilicalis*, *P. purpurea* and *P. miniata*, has postulated that the mode of germination of both carpospores and conchospores is largely governed by environmental conditions. It therefore seems clear that one of the most urgent needs in any further study of *Porphyra* is for culture work under controlled conditions, so that the exact rôle of environmental factors in the biology of this genus may be assessed. Iwasaki (1961) and Dring (1967) have already

demonstrated the value of such work in respect of the *conchocelis*-phase. Attention might well now be focussed on culture techniques for the parenchymatous phase.

#### ACKNOWLEDGEMENTS

Thanks are due to Professor W. E. Isaac for much helpful criticism and advice when this work was initiated. Also to Mr. R. H. Simons, Officer-in-Charge, South African Seaweed Research Unit, for the photography and to the Zoology Department of the University of Cape Town for identification of the barnacle.

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## A NEW SPECIES OF TITTMANNIA (BRUNIACEAE)

E. POWRIE

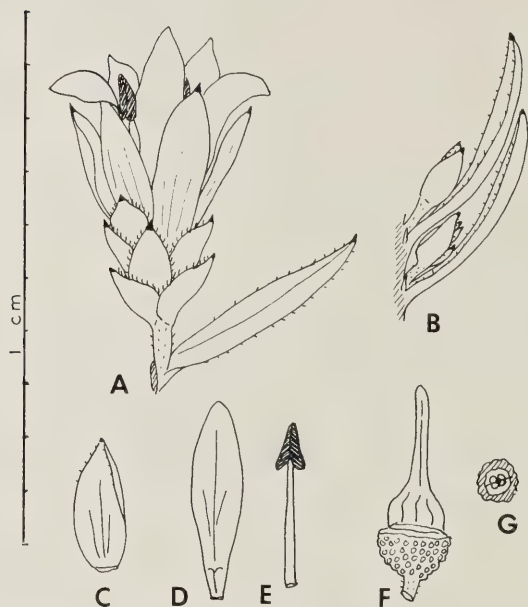
(*Bolus Herbarium, University of Cape Town*)

### *Tittmannia esterhuyseniae* Powrie sp. nov.

*Frutex* erectus, ramosissimus e basi, circiter 50 cm altus, habitu Audouiniaee. *Folia* acicularia, spiraliter inserta, ascendentia, dense imbricata, 5–6 mm longa, trigona, minute pubescentes. *Flores* racemosi, subterminales, 5–6 mm longi, albi, bracteis sepalisque eburneis, breviter pedicellati; 9–10 bracteae ad 2 mm longae, margine ciliatae, apice nigro; receptaculum verrucosum glabrum. *Petala* anguste elliptica, 4 mm longa, apice patula supra sepala imbricata, basi minute bicristata. *Stamina* inclusa, antheris lanceolatis. *Ovarium* semi-inferum, bilocularum, loculis biovulatis, apice porcatum glabrum viride; stylus duplicatus sed omnino connatus, 2 mm longus.

An erect shrub, usually about 50 cm high, with numerous ascending branches arising from a woody base and coppicing after fire, with a similar habit of growth to *Audouinia capitata* (L.) Brogniart. Branches densely clothed in spirally inserted leaves, becoming woody towards the base with dark brown bark covered in leaf scars. *Leaves* 5–6 mm long, ascending, imbricate, slightly incurved, linear-lanceolate, trigonal, scabrid with minute hairs along the margins at first, becoming glabrous, sessile, with minute pale deciduous stipules and a dark apical mucro. *Flowers* axillary in dense subterminal racemes usually 20 mm long, but occasionally up to 50 mm long. Buds of the next season's flowering already present at the tips of the branches at the time of flowering. Flowers 5–6 mm long, shortly pedicellate, surrounded by 9–10 creamy-yellow, lanceolate, scaphoid bracts, 1·5–2 mm long, fringed with small hairs and with an apical dark mucro. *Sepals* 3 mm long, lanceolate, scaphoid, creamy-yellow with a dark apex and a few small hairs along the apical margin. *Receptacle* warty and glabrous. *Petals* 4 mm long, white, narrowly ovate, with two diminutive keels at the base and curving outwards at the apex over the imbricate sepals. *Stamens* 3·5 mm long, included, with lanceolate anthers 0·75 mm long on stout filaments. *Ovary* almost completely inferior, bilocular with 2 ovules in each locule, the apex of the ovary being ridged, glabrous and bright green. *Style* double but completely connate to the apical stigma. *Fruit* (immature and





*Tittmannia esterhuyseniae* sp. nov.

A: flower in axil of leaf. B: upper leaves showing pale stipules and buds. C: sepal. D: petal. E: stamen. F: ovary. G: section through ovary to show ovules on septum.

infertile) ovoid, warty, apparently indehiscent, imbricated by the persistent bracts and crowned by the old floral parts. Large numbers of fruits were examined but no fertile seed was found, only a spongy proliferation of the septum such as is usual in unfertilised fruits of the Bruniaceae.

*Habitat:* on South-facing slopes in shale soil and Table Mountain Sandstone detritus just below the TMS krantzies near the nek between Kaaiman's Gat and Stettyn's kloof: altitude about 3,000 ft. Also on the outer Sanddrift peaks in the Hex River Mountains.

This species appears to be most closely allied to *Tittmannia laxa* (Thunberg) Presl from which it can be distinguished by its larger and more numerous creamy-yellow bracts and narrowly ovate petals.

I have pleasure in naming this plant for Miss Esterhuysen whose extensive high altitude collecting has cast much light on the genus *Tittmannia* as a whole. She first discovered it in fruit on the outer Sanddrift Peaks in October 1962, and

later discovered the second locality in Kaaiman's Gat in December 1967, when the plant was again in fruit. A joint attempt to collect it in the spring of 1968 found it once more in fruit, this time less mature. We therefore concluded that it must be an autumn flowering species and Miss Esterhuysen succeeded in collecting good flowering material in the following March.

*Distribution:* 3319 (Worcester): Outer Sanddrift Peaks, Hex River Mountains (-BC); *Esterhuysen* 31832 (BOL): Kaaiman's Gat (-CD); *Esterhuysen* 29771 (BOL); and *Esterhuysen* 32177 (Holotype BOL).



## THE VEGETATION OF THE THOMAS BAINES NATURE RESERVE

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### ABSTRACT

The vegetation of the Thomas Baines Nature Reserve, a small reserve near Grahams-town, is described. Three main types of vegetation are recognised: Macchia-Grassveld; Savannah; Forest and Thicket. Quantitative data on ground cover, stem heights and diameters and crown diameters of plants over one metre are tabulated. A list of species recorded is appended.

### INTRODUCTION

**Situation:** The Thomas Baines Nature Reserve is in the Albany District, Cape Province, about 12·9 km (8 miles) south-west of Grahamstown on the Port Elizabeth road. (33° 23' S, 26° 28' E).

**Ownership:** The reserve belongs to the Grahamstown Municipality.

**History:** The reserve was bought by the Grahamstown Municipality in 1928 as part of the area round the Howison's Poort Reservoir which was opened in 1931. Since then it has rarely been used for grazing except for a small number of animals in times of drought. In 1961 it was proclaimed a nature reserve, but it was not until 1964 that the first animals were introduced.

**Topography:** The 257 hectare (300 morgen) reserve is situated in the valley of the perennial Palmiet River and on the upper reaches of the Howison's Poort Reservoir. The distribution of land is such that about three-quarters forms a slope with an approximately south-west aspect and the remainder faces north-east. The lowest altitude is the level of the reservoir, about 335 m (1,100 ft) above sea-level, while the north-east boundary reaches about 518 m (1,700 ft). The south-western slopes reach only about 396 m (1,300 ft).

**Geology:** The underlying rock formation is principally Bokkeveld series (that is, largely shales) but along the northern boundary there is a ridge formed by Witteberg quartzite.

The soils are deep and semi-alluvial on the lower slopes but shallower elsewhere.

**Climate:** Rainfall is in the region of a mean 584 mm (23 inches) a year without very pronounced seasonal fluctuations. Resulting from the contrasting

aspects, the south-western portion tends to be warmer than elsewhere but frost may be expected generally for several months during winter.

Fauna: The most important aspect is the introduction of large mammals. These include white (square-lipped) rhino, Hartmann's zebra, several species of antelope (mainly grazing species), buffalo and warthogs.

#### ACKNOWLEDGEMENTS

The authors wish to thank the Grahamstown Municipality for permission to work in the reserve and for assistance with transport expenses, and especially Mr. T. Knowles, a member of the Board of Control, for assistance and advice. Thanks are due to Mr. C. M. Breen, Lecturer in the Department of Botany and Microbiology, Rhodes University, for very useful advice on sampling techniques and to the following students of Rhodes University who gave invaluable assistance particularly in the field: Mr. J. P. de Lange, Mr. W. D. Emmerson, Miss J. M. Haigh, Sister M. Hausmann, Mr. F. F. Jacot Guillarmod, Miss M. J. Lourens, Miss E. A. McDonald, Mr. C. G. Ward, Mr. E. van Rensburg and, most especially, Mr. B. Kenyon and Mr. K. A. J. King.

#### THE SURVEY

It was initially with the intention of determining vegetational changes that the survey was undertaken. It was considered that vegetational data, especially from long-term studies, would be of value in the formulation of policy of the stocking of the reserve. The work reported here was mainly carried out during April and May, 1969.

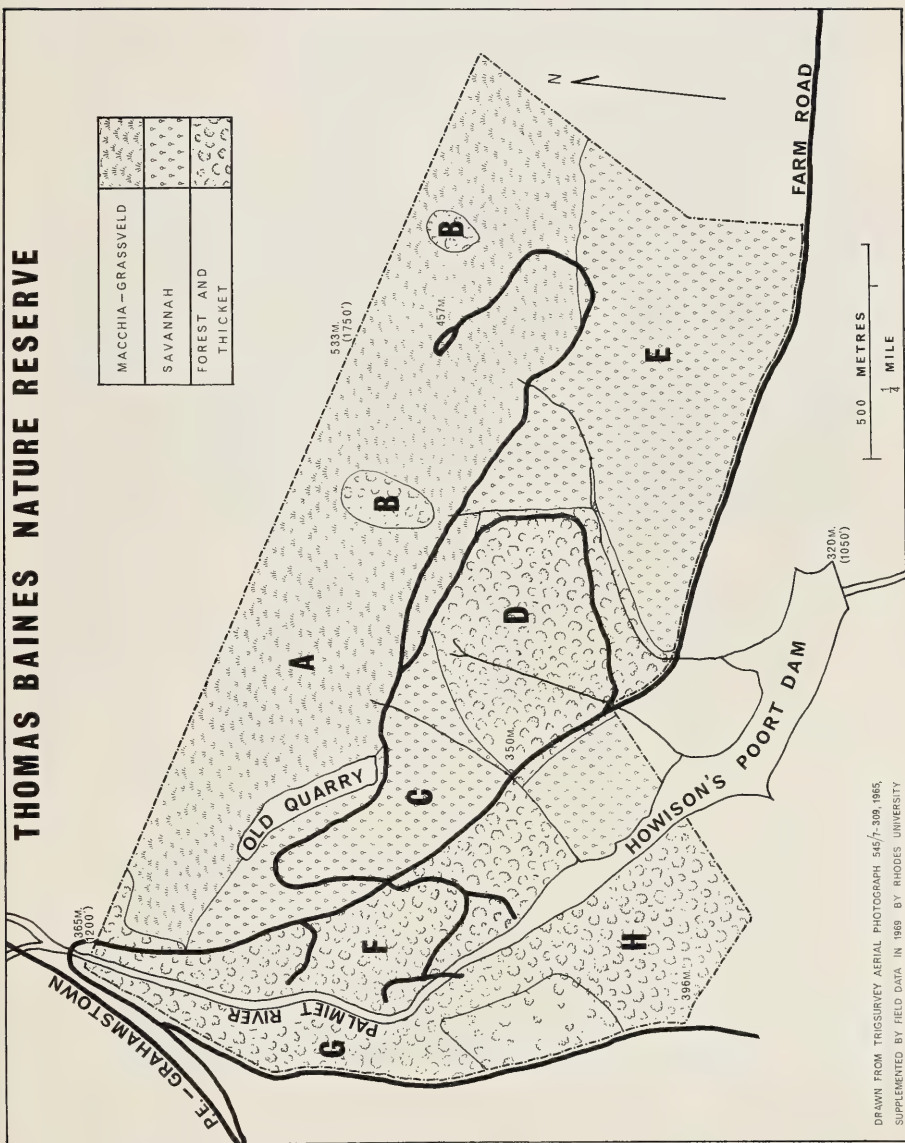
#### METHODS

With the aid of an aerial photograph (1965), the area was subjectively divided into areas A-H (see map). Within each of these areas representative sections were marked for further study. In most areas these sections include the entire areas indicated on the map, omitting only the marginal transitional portion. In area A, however, only the upper half was sampled. A number of metre-square quadrats was distributed over each area according to a pre-determined grid. In each quadrat the area covered by each species, as well as the area of exposed ground, was expressed as a percentage of the whole quadrat.

In all areas except area A, a 4×4 metre quadrat was used to compile data on the woody plants above one metre high. The 1×1 metre quadrats were situated within the larger quadrats. For each stem, distinct to, or almost to, the ground, the following data was obtained: height; diameter of the stem at one metre; mean crown diameter.

Voucher specimens of most of the species mentioned have been placed in the Rhodes University Herbarium.





In this account, tables summarising the quantitative data follow the text on each area. These show the means of: (a) percentage ground-cover and frequency of species making up one percent or more of the ground-cover; and (b) height, stem diameter and crown diameter of those woody plants over one metre high of species making up two percent or more of the stems counted. The term frequency is used to denote the percentage of quadrats in which each species was present. In referring to the percentage of ground covered it is important to take into consideration the number of quadrats in which the species occurred. High ground-cover figures based on low frequency figures must be regarded as somewhat suspect.

#### VEGETATION OF THE AREA

The reserve falls within Acocks' (1953) "False Macchia" veld type, with elements of "Eastern Province Thornveld" and "Valley Bushveld" in the vicinity. Martin and Noel (1960) place it on their map in an area of "Temperate Rainforest and Scrub", "Tussock Grassland" and "Shrub Heath and Heath—Tall Grassland".

In this paper the authors have preferred to use more general terms for the main communities but their equivalence to the terms of Acocks and of Martin and Noel is discussed.

#### VEGETATION OF THE RESERVE

No work has been published on the reserve. Although studies of the Grahamstown Nature Reserve (Martin, 1965) and of Fern Kloof (Seagrief, 1950) do include descriptions of natural vegetation not more than about 10 km (c. 6 miles) away, these communities are not very similar to those dealt with in this paper.

#### MACCHIA-GRASSVELD (AREA A)

##### (Plate 1)

This, the most continuous belt of vegetation, occupies the upper south-west facing slope and summit of the ridge forming the northern boundary of the reserve. The vegetation is generally under one metre high and forms a denser ground cover than anywhere else in the reserve, except, perhaps, for the savannah (see table 16). Though fairly uniform over most of its area, there is a tendency for the upper parts to be less dense and lower growing than the lower parts. This may be related to both greater exposure and shallower soils.

*Oldenburgia arbuscula*, which reaches three metres or more in height, is the only large woody species restricted to this area, although there are a very few small tree species, e.g. *Diospyros dichrophylla*, representing outliers of the wooded areas.



PLATE 1.

North-east corner of Thomas Baines Nature Reserve from the car park. It shows the more easterly of the two forest patches marked B on the map. The dark patches in the foreground are tufts of *Restio triticeus*, the tall stems are of *Bobartia indica*. The trees on the margin of the forest patch are mainly *Loxostylis alata* and the canopy mainly *Curtisia dentata*. The small trees to the right are *Acacia karoo*.

The most conspicuous macchia elements are perhaps the patches of *Restio triticeus* (see plate 1) and the ericoid species *Metalasia muricata* and *Selago corymbosa*. Many of the ericoid species are characteristic of rather dry or somewhat disturbed vegetation in this region, although this area is not known to have been intensively grazed for the past forty years. There are also a few species normally occurring in well-developed macchia; these include species of *Erica*, *Protea tenax* and *Leucadendron salignum*.

Grasses are abundant. These include species which are much-grazed such as *Themeda triandra* and *Harpechloa falx*. Species which appear to be less palatable include another abundant grass, *Alloteropsis semialata*.

Note on table 1:—Based on 17 quadrats, this analysis is probably fairly representative. *Streptocarpus meyeri* is restricted to the rock outcrops and probably not as important as the single record shown, suggests. *Bobartia indica*, on the other hand, is common and conspicuous because of its height. It occurred in 65% of the quadrats, making up only 0.6% of the ground cover.

The vegetation belongs to the "Shrub Heath and Heath—Tall Grassland" of Martin and Noel, but it is difficult to assign it to any of their subdivisions.

Of Acocks' types it is probably closest to "False Macchia" but shows rather strong similarities with the ground flora of the "Eastern Province Thornveld".

TABLE I  
GROUND COVER OF AREA A

	Frequency	% cover
Exposed ground . . . . .	100	35.5
<i>Selago corymbosa</i> . . . . .	59	5.4
<i>Metalasia muricata</i> . . . . .	53	4.3
<i>Aspalathus setacea</i> . . . . .	47	4.0
<i>Themeda triandra</i> . . . . .	76	3.9
<i>Alloteropsis semialata</i> . . . . .	41	3.0
<i>Heteropogon contortus</i> . . . . .	53	2.9
<i>Helichrysum anomalum</i> . . . . .	47	2.6
<i>Restio triticeus</i> . . . . .	35	2.4
<i>Alepidea capensis</i> . . . . .	47	2.3
? <i>Fimbristylis hispidula</i> . . . . .	59	2.1
<i>Helichrysum felinum</i> . . . . .	47	1.7
<i>Oxalis punctata</i> . . . . .	76	1.6
<i>Berkheya carduoides</i> . . . . .	29	1.6
<i>Senecio concolor</i> . . . . .	29	1.6
<i>Helichrysum subglomeratum</i> . . . . .	41	1.3
<i>Tristachya hispida</i> . . . . .	29	1.3
<i>Disparago ericoides</i> . . . . .	29	1.3
<i>Harpechloa falx</i> . . . . .	24	1.3
<i>Anthospermum aethiopicum</i> . . . . .	29	1.0
<i>Scabiosa albanensis</i> . . . . .	29	1.0
<i>Hypoxis rooperi</i> . . . . .	29	1.0
<i>Panicum ecklonii</i> . . . . .	18	1.0
<i>Streptocarpus meyeri</i> . . . . .	6	1.0

### SAVANNAH (AREAS C AND E)

(Plate 2)

The savannah vegetation consists of two very distinct strata, a ground layer which is usually less than 0.5 metres high and to a large extent closed, and an open tree layer of very uniform height.

These two areas of vegetation, and especially the eastern area (E), which is known to have been cleared and ploughed at least forty years ago, still show evidence of having been disturbed.

The ground cover is to a large extent similar to that of the upper slopes but lacks several of the typically macchia species (e.g. *Restio triticeus*). In addition grasses are more abundant. The species of dicotyledons in the ground layer include a large proportion of species characteristic of disturbed land in this region (e.g. *Selago corymbosa* and *Chrysocoma tenuifolia*).

The figures for bare ground (see table 16) show that there is fifty percent more exposed soil and rock in the macchia-grassveld than in the savannah vegetation.





PLATE 2.

View from the road across the centre of the western savannah area (C). The trees in the foreground are almost entirely *Acacia karoo*. The far slope includes area H and the rather open area between areas H and G. The patch of *Euphorbia triangularis* shown in plate 3 is barely discernible to the left.

However, observation suggests that, biologically, the difference may not be as great as the figures suggest, because the ground layer vegetation of the savannah is lower growing.

In the tree layer *Acacia karoo* appears to be dominant (see plate 2)—the high figure for *Rhus undulata* in area C (see table 4) resulted from a chance, single quadrat. The species are similar to those in the tree or large bush layer in the thickets, particularly area D, and show similar average measurements (see table 16). However, comparisons of total ground cover and of trees per square metre show the difference between these vegetation types clearly.

As twenty quadrats were used, ten in each area, the analysis of the ground cover is probably fairly reliable (see tables 2 and 3). In the open tree layer too few plants were encountered to give any significance to the data on the individual species in tables 4 and 5. However, taking all the tree species together the general picture is likely to be reasonably true.

This vegetation coincides with Acocks' "Eastern Province Thornveld". Martin and Noel place it in "Acacia Grassland" although they do not indicate this type in the immediate vicinity of the reserve on their map.



TABLE 2  
GROUND COVER OF AREA C

	Frequency	% cover
Exposed ground . . . . .	100	24·3
Selago corymbosa . . . . .	90	18·6
Themeda triandra . . . . .	50	7·6
Helichrysum anomalum . . . . .	70	6·7
Heteropogon contortus . . . . .	40	2·9
Tephrosia capensis . . . . .	60	2·3
Tristachya hispida . . . . .	60	2·3
Scutia indica . . . . .	20	2·3
Eragrostis curvula . . . . .	60	2·0
Chrysocoma tenuifolia . . . . .	40	1·9
Anthospermum aethiopicum . . . . .	30	1·9
Haplocarpha lyrata . . . . .	20	1·8
Schismus inermis . . . . .	10	1·8
Canthium ciliatum . . . . .	10	1·8
Cynodon dactylon . . . . .	10	1·8
Bobartia indica . . . . .	30	1·2
Elyonurus argenteus . . . . .	30	1·2
Ficinia tristachya . . . . .	30	1·2

TABLE 3  
GROUND COVER OF AREA E

	Frequency	% cover
Exposed ground . . . . .	100	21·4
Acacia karoo . . . . .	70	20·0
Xeromphis rudis . . . . .	60	9·2
Schismus inermis . . . . .	50	8·4
Chrysocoma tenuifolia . . . . .	50	7·5
Centella coriacea . . . . .	50	6·7
Sporobolus capensis . . . . .	70	5·8
Selago corymbosa . . . . .	60	5·2
Cynodon dactylon . . . . .	30	2·9
Eragrostis curvula . . . . .	60	2·4
Helichrysum anomalum . . . . .	30	2·4
Scutia indica . . . . .	10	1·8
Verbena venosa . . . . .	10	1·8
Elytropappus rhinocerotis . . . . .	10	1·8
Aloe ferox . . . . .	10	1·8
Rhus undulata . . . . .	40	1·7
Aristida congesta . . . . .	30	1·2
Eragrostis plana . . . . .	20	1·2

TABLE 4  
WOODY PLANTS OF AREA C

	Stems per square metre	Frequency	% of stems
<i>Rhus undulata</i> . . . . .	0.04	10.0	37.5
<i>Acacia karoo</i> . . . . .	0.02	30.0	18.8
<i>Xeromphis rudis</i> . . . . .	0.01	20.0	12.5
<i>Scutia indica</i> . . . . .	0.01	20.0	12.5
<i>Rhus macowanii</i> . . . . .	0.01	10.0	6.3
<i>Grewia occidentalis</i> . . . . .	0.01	10.0	6.3
<i>Chrysanthemoides monilifera</i> . . . . .	0.01	10.0	6.3

TABLE 5  
WOODY PLANTS OF AREA E

	Stems per square metre	Frequency	% of stems
<i>Acacia karoo</i> . . . . .	0.09	60.0	71.4
<i>Xeromphis rudis</i> . . . . .	0.02	10.0	14.3
<i>Rhus undulata</i> . . . . .	0.01	20.0	9.5
<i>Scutia indica</i> . . . . .	0.01	10.0	4.8

## FOREST AND THICKET (AREAS B, D, F, G AND H)

(Plates 1—3)

A range of communities has been included within this category, from those clearly dominated by trees (called forest here), especially in area B (see plate 1), to low dense thicket. Despite the small number of quadrats (five), representing the western area marked B on the map, on which the analysis of that area is based (see tables 6 and 11), field observation suggests it to be fairly typical. Among the tallest trees are *Apodytes dimidiata*, *Olea capensis*, *Cussonia spicata* and *Calodendrum capense*, all of which reach six metres or more. Low-growing thicket-forming species, especially *Scutia indica*, are frequent. In area B, however, these rarely form an entangled thicket and then usually only along the lower margins of the forest patches. In the smaller forest patch to the east, similarly situated in a depression within the macchia-grassveld, *Loxostylis alata* is particularly abundant, on the margin, and *Curtisia dentata* to the interior.

A second section in which relatively large trees occur is along the river towards the western entrance. *Vepris undulata*, *Harpephyllum caffrum* and *Ekebergia capensis* are frequently at least six metres high and in a number of cases considerably more. A single specimen of *Podocarpus falcatus*, in area G, is about

25 metres high. In the same area there is true forest with a canopy at about seven metres but individuals, e.g. *Schotia latifolia*, *Harpephyllum caffrum* and *Rhus chirindensis*, reach twice this height or more. One individual of *Schotia latifolia* in which the branches were to some extent supported by neighbouring trees, was estimated to have a crown of about 35 metres diameter. Again, low-growing species rarely form an entangled undergrowth in this forest area.

Twenty-eight quadrats were distributed over areas D, F, G and H. Although the analysis of individual areas, especially G and H, which were limited to four and five quadrats respectively, is based on inadequate samples, by taking the areas together a fairly realistic picture is obtained. The pronounced dominance of *Xeromphis rudis* immediately links these four areas (see tables 12–15). This relationship is borne out not only by the similarity in apparent structure but also by the very frequent occurrence of other species which tend to appear in all four areas, e.g. *Scutia indica*, *Phyllanthus verrucosus* and *Rhus undulata*. Unlike the forest area, with which the thickets merge, the vegetation overall tends to be low (two or three metres) and rather entangled (see table 16).

The ground cover in area D (see table 7), and to a lesser extent area F (see



PLATE 3.

The upper reaches of the Howison's Poort Reservoir, showing part of area H. In the foreground are various Cyperaceae. On the far side there are patches of *Phragmites australis* and *Typha latifolia*. The pale trees to the right are *Salix mucronata*, with *Euphorbia triangularis* behind.

table 8), shows very slight affinities with that of the savannah, e.g. *Schismus inermis* (see tables 2 and 3). Area B has a ground flora of species largely confined to that area (see table 6). The most obvious difference between the thicket vegetation on the southern slopes (G and H) and the northern slope (F) is in the ground cover. While the table gives 65·9% exposed ground for area F and 82·5 and 87·5% for slopes G and H (see tables 8—10), observation suggests that the differences are likely to be even greater. This difference is no doubt largely a result of the drier conditions on the southern slopes. It is interesting that no such marked difference is reflected in the figures for the woody plants (see tables 13—15).

The unlabelled area shown on the map between areas G and H appears to represent a disturbed form of the vegetation on either side of it. While the species are similar to those in the adjacent areas, the vegetation is very much more open.

Of the larger species, *Plumbago auriculata* is eaten but there is generally not much evidence of browsing. *Schismus inermis*, *Panicum* spp. and *Justicia bowiei* are among the most important grazing species.

The forest types include many species in common with Acocks' "Ngongoni Veld" but *Aristida junciformis* (the 'Ngongoni) is rare or absent. Martin and Noel's "Warm Temperate Forest" subformation of their "Temperate Rainforest and Scrub" has several aspects in common with this vegetation. The thicket vegetation probably belongs to the "southern variation of the Valley Bushveld" of Acocks. It differs from most of the Valley Bushveld in the relative scarcity of large succulents, although several such species do occur. In Martin and Noel's system, the thickets would belong to the "Warm Temperate Forest Scrub" subdivision of their "Temperate Rainforest and Scrub".

TABLE 6  
GROUND COVER OF AREA B

	Frequency	% cover
Exposed ground . . . . .	100	77·5
<i>Plectranthus verticillatus</i> . . . . .	60	2·6
<i>Cyperus albostratus</i> . . . . .	40	2·0
<i>Plectranthus madagascariensis</i> . . . . .	40	1·1
<i>Asplenium splendens</i> . . . . .	20	1·0
<i>Scutia indica</i> . . . . .	20	1·0

TABLE 7  
GROUND COVER OF AREA D

	Frequency	% cover
Exposed ground . . . . .	100	51.7
Schismus inermis . . . . .	40	6.6
Chrysocoma tenuifolia . . . . .	60	4.0
Selago corymbosa . . . . .	60	2.3
Centella coriacea . . . . .	20	2.3
Acacia karoo . . . . .	50	1.8
Ctenomeria cordata . . . . .	10	1.8
Grass indet. . . . .	10	1.8
Teucrium capense . . . . .	40	1.7
Themeda triandra . . . . .	30	1.7
Cynodon dactylon . . . . .	30	1.2
Cyanotis speciosa . . . . .	20	1.1

TABLE 8  
GROUND COVER OF AREA F

	Frequency	% cover
Exposed ground . . . . .	100	65.9
Themeda triandra . . . . .	22	4.8
Schismus inermis . . . . .	22	2.5
Helichrysum rosum . . . . .	44	2.4
Xeromphis rudis . . . . .	33	1.3
Eragrostis curvula . . . . .	22	1.2
Additional particularly frequent species in this area:		
Oxalis punctata . . . . .	55	0.8
Selago corymbosa . . . . .	44	0.8
Panicum deustum . . . . .	44	0.8

TABLE 9  
GROUND COVER OF AREA G

	Frequency	% cover
Exposed ground . . . . .	100	*87.5
Xeromphis rudis . . . . .	25	1.4
Euclea undulata . . . . .	25	1.4
Stipa dregeana . . . . .	25	1.4
Additional particularly frequent species in this area:		
Hypoestes verticillaris . . . . .	50	0.3
Crassula spathulata . . . . .	50	0.3

\*This figure is probably much too low (see text, p. 377)



TABLE 10  
GROUND COVER OF AREA H

	Frequency	% cover
Exposed ground . . . . .	100	82.5
<i>Sansevieria thyrsoflora</i> . . . . .	80	2.4
<i>Panicum deustum</i> . . . . .	80	1.4
<i>Hypoestes verticillaris</i> . . . . .	60	1.3
<i>Aloe ferox</i> . . . . .	20	1.1
<i>Panicum maximum</i> . . . . .	20	1.1
<i>Diospyros dichrophylla</i> . . . . .	20	1.1
<i>Xeromphis rudis</i> . . . . .	20	1.1
<i>Euclea undulata</i> . . . . .	20	1.1
<i>Plumbago auriculata</i> . . . . .	20	1.1

TABLE 11  
WOODY PLANTS OF AREA B

	Stems per square metre	Frequency	% of stems
<i>Olea capensis</i> . . . . .	0.16	40	19.7
<i>Maytenus heterophylla</i> . . . . .	0.14	80	16.7
<i>Scutia indica</i> . . . . .	0.10	100	12.1
<i>Pavetta lanceolata</i> . . . . .	0.06	20	7.6
<i>Rhoicissus digitata</i> . . . . .	0.04	20	4.5
<i>Clausena inaequalis</i> . . . . .	0.04	20	4.5
<i>Xeromphis rudis</i> . . . . .	0.04	20	4.5
<i>Apodytes dimidiata</i> . . . . .	0.03	20	3.0
<i>Rhus chirindensis</i> . . . . .	0.03	20	3.0
<i>Harpephyllum capensis</i> . . . . .	0.03	20	3.0
<i>Scolopia mundii</i> . . . . .	0.03	20	3.0
<i>Diospyros dichrophylla</i> . . . . .	0.03	20	3.0
<i>Canthium ventosum</i> . . . . .	0.03	20	3.0
<i>Acacia karo</i> . . . . .	0.03	20	3.0

TABLE 12  
WOODY PLANTS OF AREA D

	Stems per square metre	Frequency	% of stems
<i>Xeromphis rudis</i> . . . . .	0.18	60	28.8
<i>Phyllanthus verrucosus</i> . . . . .	0.13	20	20.6
<i>Acacia karo</i> . . . . .	0.06	60	10.3
<i>Rhus undulata</i> . . . . .	0.06	40	10.3
<i>Canthium ventosum</i> . . . . .	0.06	10	10.3
<i>Scutia indica</i> . . . . .	0.04	10	7.2
<i>Lycium</i> sp. . . . .	0.02	10	3.1
<i>Maytenus heterophylla</i> . . . . .	0.02	10	3.1
<i>Diospyros dichrophylla</i> . . . . .	0.01	10	2.1

TABLE 13  
WOODY PLANTS OF AREA F

	Stems per square metre	Frequency	% of stems
<i>Xeromphis rudis</i> . . . . .	0.98	77.7	60.0
<i>Hippobromus pauciflora</i> . . . . .	0.15	33.3	9.4
<i>Rhus undulata</i> . . . . .	0.09	55.5	5.5
<i>Rhus incisa</i> . . . . .	0.08	11.1	4.7
<i>Acacia karoo</i> . . . . .	0.05	55.5	3.0
<i>Grewia occidentalis</i> . . . . .	0.05	44.4	3.0
<i>Aloe ferox</i> . . . . .	0.04	44.4	2.6

TABLE 14  
WOODY PLANTS OF AREA G

	Stems per square metre	Frequency	% of stems
<i>Xeromphis rudis</i> . . . . .	0.44	50	33.7
<i>Euclea undulata</i> . . . . .	0.25	25	19.3
<i>Scutia indica</i> . . . . .	0.19	50	14.5
<i>Asparagus africanus</i> . . . . .	0.11	50	7.2
<i>Maytenus heterophylla</i> . . . . .	0.08	25	6.0
<i>Trimeria trinervis</i> . . . . .	0.06	25	4.8
<i>Aloe ferox</i> . . . . .	0.03	25	2.4
<i>Rhus undulata</i> . . . . .	0.03	25	2.4
<i>Grewia occidentalis</i> . . . . .	0.03	25	2.4

TABLE 15  
WOODY PLANTS OF AREA H

	Stems per square metre	Frequency	% of stems
<i>Xeromphis rudis</i> . . . . .	0.69	40	26.6
<i>Phyllanthus verrucosus</i> . . . . .	0.48	40	18.4
<i>Capparis sepiaria</i> . . . . .	0.26	40	10.1
<i>Olea africana</i> . . . . .	0.18	20	6.8
<i>Euclea undulata</i> . . . . .	0.16	40	6.3
<i>Euphorbia triangularis</i> . . . . .	0.14	20	5.3
<i>Rhoicissus digitata</i> . . . . .	0.13	100	4.8
<i>Plumbago auriculata</i> . . . . .	0.10	40	3.9
<i>Sarcostemma viminalis</i> . . . . .	0.06	40	2.4
<i>Diospyros dichrophylla</i> . . . . .	0.06	20	2.4
<i>Schotia latifolia</i> . . . . .	0.06	40	2.4

TABLE 16  
SUMMARY OF DATA FOR ALL AREAS

Area	WOODY PLANTS				Exposed ground %
	Stems per square metre	Height metres	Stem diameter centimetres	Crown diameter metres	
A	—	—	—	—	35.5
C	0.1	2.5	3.9	1.6	24.3
E	0.1	1.8	3.5	2.2	21.4
B	0.8	4.2	3.8	1.9	77.5
D	0.6	2.1	3.5	0.6	51.7
F	1.6	2.0	2.7	1.1	65.9
G	1.3	2.2	3.9	2.0	87.5
H	2.6	1.8	3.3	1.6	82.5

## RIVERINE VEGETATION

The vegetation of the banks of the river and reservoir has not been thoroughly examined. *Salix mucronata* is common and a conspicuous tree along the banks of the river. Monocotyledons play a major role in the herbaceous vegetation. *Stenotaphrum secundatum* and *Cynodon dactylon* are very general species, forming much of the ground cover. *Prionium serratum* occurs in the upper portions of the river within the reservoir and *Cyperus textilis* is locally frequent along the margin of the reservoir.

## ALIEN SPECIES

Several alien species are well established. Of these, *Opuntia megacantha*, in the thicket areas, is probably spreading fastest. Other potentially important species are *Acacia mearnsii* along the river and *A. ?longifolia* in area D, and *Hakea acicularis* also along the river. *Agave americana* is locally frequent but not apparently spreading to any extent.

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## LIST OF SPECIES RECORDED IN THE THOMAS BAINES RESERVE 1969

(This list does not claim any degree of completeness. It only records specimens collected or noted during the period of the work described).

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
PTERIDOPHYTES									
Mohria caffrorum (L.) Desv. . . . .	×			×	×				
Pteridium aquilinum (L.) Kuhn . . . . .	×					×			
Cheilanthes hirta Sw. . . . .	×	×							
Pellaea calomelanos (Sw.) Link . . . . .	×								
P. viridis (Forsk.) Prantl . . . . .	×		×	×	×			×	×
Blechnum australe L. . . . .		×							
Asplenium rutaefolium (Berg.) Kunze . . . . .		×							
A. splendens Kunze . . . . .		×							
Ceterach cordatum (Thunb.) Desv. . . . .				×		×		×	
GYMNOSPERMS									
Podocarpus falcatus Mirb. . . . .							×		
MONOCOTYLEDONS									
<i>Typhaceae</i>									
Typha latifolia L. . . . .								×	
<i>Gramineae</i>									
Miscanthidium capense (Nees) Stapf . . . . .							×		
Heteropogon contortus Beauv. . . . .	×		×						
Elyonurus argenteus Nees . . . . .			×						
Cymbopogon marginatus (Steud.) Stapf . . . . .			×						
Hyparrhenia hirta (L.) Stapf . . . . .			×						
Themeda triandra Forsk. . . . .	×		×	×		×			
Panicum aquinerve Nees . . . . .	×	×				×	×		
P. ?chusqueoides Hack. . . . .		×							
P. deustum Thunb. . . . .		×				×	×	×	
P. ecklonii Nees . . . . .	×			×					
P. maximum Jacq. . . . .		×	×	×	×	×		×	
Allotriopsis semialata (R. Br.) Hitch. . . . .	×		×						
Brachiaria serrata (Spreng.) Stapf . . . . .	×		×	×	×	×			
Rhynchelytrum setifolium (Stapf) Chiov. . . . .					×				
Digitaria diagonalis (Nees) Stapf . . . . .	×								
D. eriantha Steud. . . . .	×								
Oplismenus hirtellus (L.) Beauv. . . . .		×							
Stenotaphrum secundatum (Walt.) Kuntze . . . . .						×	×	×	
Ehrharta erecta Lam. . . . .				×					
Aristida congesta Roem. & Schult. . . . .				×	×				
Stipa dregeana Steud. . . . .						×	×		

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>Sporobolus capensis</i> (Willd.) Kunth			×	×	×	×			
<i>Helictotrichon turgidulum</i> (Stapf) Schweick.					×				
<i>Tristachya hispidula</i> (L.f.) K. Schum.	×		×						
<i>Danthonia disticha</i> Nees	×								
<i>Pentaschistis angustifolia</i> (Nees) Stapf	×		×	×					
<i>Cynodon dactylon</i> (L.) Pers.			×	×	×	×			
<i>Harpechloa falx</i> (L.f.) Kuntze	×								
<i>Phragmites australis</i> (Cav.) Trin. ex Steud.						×		×	
<i>Eragrostis capensis</i> (Thunb.) Trin.					×				
<i>E. curvula</i> (Schrud.) Nees			×	×	×	×	×		
<i>E. obtusa</i> Munro				×	×	×			
<i>E. plana</i> Nees					×				
<i>E. racemosa</i> (Thunb.) Steud.						×			
<i>Schismus inermis</i> (Stapf) Hubb.	×		×	×	×	×			
<i>Cyperaceae</i>									
<i>Cyperus albostratus</i> Schrad.				×					
<i>Cyperus textilis</i> Thunb.						×		×	
<i>Pycnus polystachyus</i> Beauv.						×	×		
<i>Mariscus capensis</i> Schrad.			×		×				
<i>Kyllinga melanospora</i> Nees	×		×	×	×				
<i>Ficinia filiformis</i> (Lam.) Schrad.			×						
<i>F. tristachya</i> (Rottb.) Nees			×		×				
<i>Ficinia</i> spp.	×								
<i>Fimbristylis hispidula</i> (Vahl) Kunth	×								
<i>Bulbostylis humilis</i> Kunth			×		×				
<i>Tetraria cuspidata</i> C.B.C1.	×								
<i>Schoenoxiphium sparteum</i> (Wahl.) Kuek.			×		×	×	×		
<i>Carex zuluensis</i> C.B.C1.		×							
<i>Restionaceae</i>									
<i>Restio triticeus</i> Rottb.	×								
<i>Leptocarpus paniculatus</i> Mast.							×		
<i>Commelinaceae</i>									
<i>Commelina africana</i> L.							×		
<i>C. krebsiana</i> Kunth			×		×				
<i>Commelina</i> sp.	×	×		×		×	×	×	
<i>Cyanotis speciosa</i> (L.f.) Hassk.	×			×		×	×	×	
<i>Juncaceae</i>									
<i>Prionium serratum</i> (L.f.) Drege						×			
<i>Liliaceae</i>									
<i>Bulbine natalensis</i> Bak.									×
<i>Eriospermum</i> spp.	×			×	×	×	×		
<i>Kniphofia uvaria</i> (L.) Hook. f.	×								
<i>Aloe ferox</i> Mill.		×		×	×	×	×	×	
<i>A. myriacantha</i> (Haw.) Roem. & Schult.	×								



	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>A. pluridens</i> Haw. . . . .	×								
<i>Tulbaghia alliacea</i> L.f. . . . .	×								
<i>Drimia anomala</i> Benth. . . . .								×	
<i>Scilla lanceaeifolia</i> (Jacq.) Bak. . . . .	×					×			
<i>S. saturata</i> Bak. . . . .	×								
<i>Ornithogalum</i> spp. . . . .	×		×						
<i>Asparagus africanus</i> Lam. . . . .						×	×	×	
<i>A. asparagoides</i> (L.) Wight . . . . .								×	
<i>A. crassiciadus</i> Jess. . . . .								×	
<i>A. macowanii</i> Bak. . . . .		×							
<i>A. mucronatus</i> Jess. . . . .								×	
<i>A. racemosus</i> Willd. . . . .						×	×		
<i>A. setaceus</i> (Kunth) Jess. . . . .				×		×	×	×	
<i>A. striatus</i> (L.f.) Thunb. . . . .						×	×	×	
<i>A. suaveolens</i> Burch. . . . .	×		×			×		×	
<i>A. subulatus</i> (Thunb.) L.f. . . . .						×	×		
<i>Dracaena hookeriana</i> K. Koch . . . . .		×				×	×	×	
<i>Sansevieria thyrsiflora</i> Thunb. . . . .		×				×	×	×	
<i>Agave americana</i> L. . . . .					×				
<i>Amaryllidaceae</i>									
<i>Boophane disticha</i> Herb. . . . .	×		×						
<i>Clivia nobilis</i> Lindl. . . . .							×		
<i>Hypoxis argentea</i> Harv. . . . .	×					×			
<i>H. rooperi</i> Moore . . . . .	×					×			
<i>H. ?zeyheri</i> Bak. . . . .			×						
<i>Hypoxis</i> sp. . . . .	×								
<i>Iridaceae</i>									
<i>Romulea autumnalis</i> L. Bol. . . . .						×			
<i>Dietes vegeta</i> (Mill.) N.E. Br. . . . .				×		×		×	
<i>Bobartia indica</i> L. . . . .	×		×						
<i>Aristea anceps</i> Eckl. . . . .	×								
<i>A. cognata</i> N.E. Br. . . . .				×	×				
<i>A. pusilla</i> (Thunb.) Ker-Gawl. . . . .	×								
<i>Aristea</i> sp. . . . .							×		
<i>Tritonia securigera</i> (Ait.) Ker-Gawl. . . . .				×	×	×	×	×	
<i>Gladiolus maculatus</i> Sweet . . . . .	×								
<i>?Watsonia</i> sp. . . . .	×								
<i>Orchidaceae</i>									
<i>Orchid</i> (?sp.) . . . . .	×					×			
DICOTYLEDONS									
<i>Salicaceae</i>									
<i>Salix mucronata</i> Thunb. . . . .						×	×	×	
<i>Moraceae</i>									
<i>Ficus capensis</i> Thunb. . . . .						×	×		
<i>Proteaceae</i>									
<i>Protea tenax</i> R. Br. . . . .	×								
<i>Leucadendron salignum</i> Berg. . . . .	×								
<i>Hakea acicularis</i> R. Br. . . . .						×			

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>Loranthaceae</i>									
<i>Viscum obscurum</i> Thunb. . . . .				×		×			×
<i>V. rotundifolium</i> L.f. . . . .				×	×	×		×	
<i>Santalaceae</i>									
<i>Rhoiacarpus capensis</i> A.DC. . . .		×						×	
<i>Colpoön compressum</i> Berg. . . . .						×			×
<i>Osyridicarpus schimperianus</i> (Hochst.) A.DC. . . . .							×		
<i>Thesium strictum</i> Berg. . . . .	×								
<i>Amaranthaceae</i>									
<i>Pupalia lappacea</i> (L.) Juss. . . . .									×
<i>Aizoaceae</i>									
<i>Aizoon glinoides</i> L.f. . . . .				×				×	
<i>Aptenia cordifolia</i> (L.) Schw. . . .									×
<i>Carpobrotus edulis</i> (L.) N.E. Br. . .						×	×	×	
? <i>Delosperma</i> spp. . . . .					×	×	×	×	
<i>Lampranthus ?spectabilis</i> (Haw.) N.E. Br. . . . .	×								
? <i>Lampranthus</i> sp. . . . .								×	
<i>Cruciferae</i>									
<i>Heliophila elongata</i> (Thunb.) DC. .	×								
<i>Capparidaceae</i>									
<i>Capparis sepiaria</i> L. . . . .						×	×	×	
<i>Maerua racemulosa</i> (DC.) Gilg & Bened. . . . .		×							
<i>Crassulaceae</i>									
<i>Kalanchoe rotundifolia</i> Haw. . . .				×	×				
<i>Crassula</i> sp. cf. <i>albanensis</i> Schonl. .							×	×	
<i>C. ?cultrata</i> L. . . . .				×					
<i>C. ericoides</i> Haw. . . . .	×								
<i>C. lycopodioides</i> Lam. . . . .	×								
<i>C. ?obvallata</i> L. . . . .	×								
<i>C. portulacea</i> Lam. . . . .								×	
<i>C. rosularis</i> Haw. . . . .	×								
<i>C. spathulata</i> Thunb. . . . .		×					×	×	
<i>C. tetragona</i> L. . . . .				×	×	×			
<i>C. trachysantha</i> (Eckl. & Zeyh.) Harv. . . . .								×	
<i>C. turrita</i> Thunb. . . . .	×								
<i>C. vaginata</i> Eckl. & Zeyh. . . . .	×								
<i>Pittosporaceae</i>									
<i>Pittosporum viridiflorum</i> (Putt.) Sims . . . . .		×		(×) <sup>1</sup>		×			
<i>Rosaceae</i>									
<i>Rubus pinnatus</i> Willd. . . . .	×		×						
<i>Cliffortia strobilifera</i> Murr. . . .						×	×	×	×
<i>Leguminosae</i>									
<i>Acacia karoo</i> Hayne . . . . .	×	×	×	×	×	×		×	

[illegible]

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>Euphorbiaceae</i>									
<i>Phyllanthus verrucosus</i> Thunb.	×			×			×	×	
<i>Croton rivularis</i> E. Mey. ex Muell.-Arg.								×	
<i>Ctenomeria cordata</i> Harv.				×			×		
<i>Dalechampia capensis</i> Spreng. f.								×	
<i>Ricinus communis</i> L.							×		
<i>Clusia heterophylla</i> Thunb.	×								
<i>C. laxa</i> Eckl.			×	×	×	×			×
? <i>Clusia</i> sp.			×						
<i>Euphorbia bupleurifolia</i> Jacq.								×	×
<i>E. fimbriata</i> Scop.								×	
<i>E. kraussiana</i> Bernh.		×							
<i>E. polygona</i> Haw.									×
<i>E. sclerophylla</i> Boiss.	×								
<i>E. silenifolia</i> (Haw.) Sweet	×								
<i>E. triangularis</i> Desf.				(×) <sup>1</sup>				×	
<i>Anacardiaceae</i>									
<i>Harpephyllum caffrum</i> Bernh.		×				×	×	×	
<i>Loxostylis alata</i> Spreng.	×	×							
<i>Rhus chirindensis</i> Bak. f.		×				×			
<i>R. incisa</i> L.f.						×	×		
<i>R. lucida</i> L.						×			
<i>R. macowanii</i> Schonl.			×		×	×			
<i>R. refracta</i> Eckl. & Zeyh.					×	×	×	×	
<i>R. undulata</i> Jacq.	×	×	×	×	×	×	×	×	×
<i>Celastraceae</i>									
<i>Maytenus heterophylla</i> (Eckl. & Zeyh.) N. Robson		×	×	×		×	×		
<i>M. nemorosa</i> (Eckl. & Zeyh.) Loes.								×	
<i>M. peduncularis</i> (Sond.) Loes.								×	
<i>Pterocelastrus tricuspidatus</i> (Lam.) Sond.		×	×						×
<i>Cassine tetragona</i> (Thunb.) Loes.		×	×	(×) <sup>1</sup>		×			
<i>Icacinales</i>									
<i>Apodytes dimidiata</i> E. Mey. ex Arn.		×		(×) <sup>1</sup>					
<i>Sapindaceae</i>									
<i>Allophylus decipiens</i> (Sond.) Radlk.						×		×	
<i>Pappea capensis</i> Eckl. & Zeyh.							×	×	
<i>Hippobromus pauciflora</i> (L.) Radlk.		×				×	×		×
<i>Rhamnaceae</i>									
<i>Scutia indica</i> Brongn.	×	×	×	×	×	×	×	×	×
<i>Phyllica paniculata</i> Willd.							×		
<i>Vitaceae</i>									
<i>Rhoicissus digitata</i> (L.f.) Gilg & Brandt		×		×		×	×	×	
<i>R. tomentosa</i> (Lam.) Wild & Drummond		×					×		
<i>R. tridentata</i> (L.f.) Wild & Drummond		×		×					

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>Tiliaceae</i>									
<i>Grewia occidentalis</i> L. . . . .			×	×	×	×	×	×	×
<i>Malvaceae</i>									
<i>Abutilon sonneratianum</i> Cav. . . . .						×	×	×	
<i>Sida dregei</i> Burtt Davy . . . . .				×		×	×	×	
<i>S. triloba</i> Cav. . . . .				×	×	×	×	×	
<i>Hibiscus</i> sp. cf. <i>leiospermus</i> Harv. . . . .					×	×			
<i>H. pusillus</i> Thunb. . . . .						×			
<i>Hibiscus</i> sp. . . . .			×						
<i>Sterculiaceae</i>									
<i>Melhania didyma</i> Eckl. & Zeyh. . . . .				×					
<i>Hermannia candicans</i> Ait. . . . .				×	×	×			
<i>H. flammea</i> Jacq. . . . .	×			×		×			
<i>Ochnaceae</i>									
<i>Ochna arborea</i> Burch. . . . .						×			
<i>Guttiferae</i>									
<i>Hypericum lalandii</i> Chois. . . . .	×								
<i>Flacourtiaceae</i>									
<i>Scolopia mundii</i> Warb. . . . .							×	×	
<i>S. zeyheri</i> Szyszyl. . . . .				×		×	×	×	×
<i>Trimeria trinervis</i> Harv. . . . .		×				×	×		
<i>Dovyalis rhamnoides</i> (Burch. ex DC.) Harv. . . . .		×				×			
<i>Cactaceae</i>									
<i>Opuntia megacantha</i> Salm Dyck . . . . .				×	×		×	×	
<i>Thymelaeaceae</i>									
<i>Gnidia anthylloides</i> (L.f.) Gilg . . . . .	×								
<i>G. nodiflora</i> Meissn. . . . .			×						
<i>G. racemosa</i> Thunb. . . . .				×		×	×		
<i>G. stypheloides</i> Meissn. . . . .	×								
<i>Struthiola argentea</i> Lehm. . . . .	×								
<i>Passerina ?vulgaris</i> Thoday . . . . .			×			×			
<i>Myrtaceae</i>									
<i>Eugenia zeyheri</i> Harv. . . . .		×							
<i>Araliaceae</i>									
<i>Cussonia spicata</i> Thunb. . . . .	×	×	×			×	×		
<i>Umbelliferae</i>									
<i>Centella coriacea</i> Nannf. . . . .			×	×	×	×			
<i>Alepidea capensis</i> (Berg.) R. A. Dyer . . . . .	×								
<i>Cornaceae</i>									
<i>Curtisia dentata</i> (Burm.f.) C.A. Sm. . . . .		×							
<i>Ericaceae</i>									
<i>Erica caffra</i> L. . . . .						×	×		



	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>E. cerinthoides</i> L. . . . .	×								
<i>E. glumaeiflora</i> Klotzsch . . . .	×								
<i>E. sp. cf. leucopelta</i> Tausch . . .			×		×				
<i>E. nemorosa</i> Klotzsch ex Benth. .						×	×	×	
<i>E. sp.</i> . . . . .						×			
<i>Myrsinaceae</i>									
<i>Rapanea melanophloeos</i> (L.) Mez.		×							
<i>Plumbaginaceae</i>									
<i>Plumbago auriculata</i> Lam. . . .				×	×	×	×	×	
<i>Sapotaceae</i>									
<i>Sideroxylon inerme</i> L. . . . .		×				×			
<i>Ebenaceae</i>									
<i>Diospyros dichrophylla</i> (Gand.) De Wint . . . . .	×	×	×	×		×	×	×	×
<i>D. whyteana</i> (Hiern) F. White . .				×					
<i>Euclea schimperi</i> (A.DC.) Dandy .						×			
<i>E. undulata</i> Thunb. . . . .			×			×	×	×	×
<i>Oleaceae</i>									
<i>Olea africana</i> Mill. . . . .		×				×	×	×	
<i>O. capensis</i> L. . . . .		×				×			
<i>Linociera foveolata</i> (E. Mey.) Knobl. . . . .		×							
<i>Jasminum angulare</i> Vahl . . . .								×	
<i>Salvadoraceae</i>									
<i>Azima tetracantha</i> Lam. . . . .				×		×		×	
<i>Loganiaceae</i>									
<i>Buddleia saligna</i> Willd. . . . .				×		×	×		
<i>Gentianaceae</i>									
<i>Chironia tetragona</i> L.f. . . . .	×								
<i>Apocynaceae</i>									
<i>Carissa bispinosa</i> (L.) Desf. . .	×	×		×		×	×	×	
<i>Asclepiadaceae</i>									
<i>Asclepias physocarpa</i> (E. Mey.) Schltr. . . . .						×			
<i>Cynanchum ellipticum</i> (Harv.) R. A. Dyer . . . . .							×		
<i>Sarcostemma viminalis</i> (L.) R. Br. .				×		×	×	×	
<i>Secamone alpini</i> Schult. . . . .						×	×		×
<i>S. frutescens</i> (E. Mey.) Decne. . .						×	×		
<i>Ceropegia ?carnosa</i> E. Mey. . . .							×	×	
<i>Stapeliad</i> (?sp.) . . . . .								×	
<i>Marsdenia floribunda</i> (E. Mey.) N.E. Br. . . . .							×		
<i>Boraginaceae</i>									
<i>Ehretia rigida</i> (Thunb.) Druce . .				×				×	

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>Verbenaceae</i>									
<i>Verbena venosa</i> Gill. . . . .				×	×				
<i>Lantana rugosa</i> Thunb. . . . .					×	×			
<i>Lippia javanica</i> (Burm.f.) Spreng. .			×	×					
<i>Labiatae</i>									
<i>Teucrium capense</i> Thunb. . . . .			×	×	×	×			
<i>Leonotis leonurus</i> (L.) Ait. . . .						×			×
<i>Salvia repens</i> Burch. ex Benth. . .						×		×	
<i>Plectranthus madagascariensis</i> (Pers.) Benth. . . . .		×		×				×	
<i>P. verticillatus</i> (L.f.) Druce . . .		×							
<i>Plectranthus</i> sp. . . . .								×	
<i>Solanaceae</i>									
<i>Lycium</i> sp. . . . .				×				×	
<i>Datura stramonium</i> L. . . . .				×		×	×		
<i>Scrophulariaceae</i>									
<i>Diascia capsularis</i> Benth. . . . .	×								
<i>Halleria lucida</i> L. . . . .		×							
<i>Sutera campanulata</i> (Benth.) Kuntze . . . . .	×		×	×		×			
<i>S. pinnatifida</i> (Benth.) Kuntze . .				×	×				
<i>Gesneriaceae</i>									
<i>Streptocarpus meyeri</i> Burtt . . .	×								
<i>Selaginaceae</i>									
<i>Selago corymbosa</i> L. . . . .	×		×	×	×	×	×		×
<i>Walafrida geniculata</i> (L.f.) Rolfe .								×	
<i>Acanthaceae</i>									
<i>Thunbergia atriplicifolia</i> Lindl. .				×		×			
<i>T. capensis</i> Retz. . . . .	×		×						
<i>Chaetacanthus setiger</i> (Pers.) Lindl.	×		×		×		×		
<i>Hypoestes aristata</i> (Vahl) R. Br. .						×	×		
<i>H. verticillaris</i> R. Br. . . . .		×		×		×	×	×	
<i>Justicia bowiei</i> C.B.Cl. . . . .							×	×	
<i>Rubiaceae</i>									
<i>Kohautia amatymbica</i> Eckl. & Zeyh. . . . .	×								
<i>Burchellia bubalina</i> (L.f.) Sims . .	×		×	×		×			×
<i>Xeromphs rudis</i> (E. Mey. ex Harv.) Codd . . . . .	×	×	×	×	×	×	×	×	×
<i>Canthium ciliatum</i> (Sond.) Kuntze .		×	×			×	×		
<i>C. obovatum</i> Klotzsch . . . . .	×								
<i>C. ventosum</i> (L.) S. Moore . . . .		×				×		×	×
<i>Pavetta lanceolata</i> Eckl. . . . .		×							
<i>P. revoluta</i> Hochst. . . . .				×					
<i>Psychotria capensis</i> (Eckl.) Vátke .	×	×		×		×	×		
<i>Galopina circaeoides</i> Thunb. . . .			×						
<i>Anthospermum aethiopicum</i> L. . .	×		×		×				
<i>A. herbaceum</i> L.f. . . . .		×							

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>Dipsacaceae</i>									
<i>Scabiosa albanensis</i> R. A. Dyer . . . . .	×								
<i>Cucurbitaceae</i>									
<i>Coccinia quinqueloba</i> (Thunb.) Cogn. . . . .		×							
<i>Campanulaceae</i>									
<i>Wahlenbergia capillacea</i> (Thunb.) A.DC. . . . .	×								
<i>W. stellarioides</i> Cham. . . . .			×						
<i>Cyphia volubilis</i> Willd. . . . .	×								
<i>Lobelia anceps</i> Thunb. . . . .									×
<i>L. tomentosa</i> L. . . . .	×						×		
<i>Monopsis scabra</i> Urb. . . . .						×			
<i>Compositae</i>									
<i>Vernonia capensis</i> (Houtt.) Druce . . . . .			×						
<i>Corymbium africanum</i> L. . . . .	×								
<i>Aster filifolius</i> Vent. . . . .								×	
<i>A. hispidus</i> Bak. . . . .	×								
<i>A. muricatus</i> (Thunb.) Nees . . . . .						×			
<i>A. ?sp.</i> . . . . .			×	×					
<i>Erigeron canadense</i> L. . . . .						×			
<i>Microglossa mespilifolia</i> (Less.) Robins. . . . .									×
<i>Chrysocoma tenuifolia</i> Berg. . . . .			×	×	×	×			×
<i>Brachylaena elliptica</i> (Thunb.) Less. . . . .						×			×
<i>Tarchonanthus camphoratus</i> L. . . . .	×								
<i>Helichrysum anomalum</i> Less. . . . .	×		×	×	×	×			
<i>H. ?appendiculatum</i> (L.f.) Less. . . . .	×								
<i>H. felinum</i> (Thunb.) Less. . . . .	×								
<i>H. nudifolium</i> (L.) Less. . . . .	×		×			×			
<i>H. pedunculare</i> (L.) Less. . . . .	×			×	×	×			
<i>H. rosum</i> (Berg.) Less. . . . .	×			×		×	×		×
<i>H. squamosum</i> Thunb. . . . .	×								
<i>H. subglomeratum</i> Less. . . . .	×								
<i>Leontonyx squarrosa</i> (L.) DC. . . . .	×								
<i>Disparago ericoides</i> Gaertn. . . . .	×					×			
<i>Elytropappus rhinocerotis</i> (L.f.) Less. . . . .	×		×		×	×			
<i>Metalasia gnaphalodes</i> (Thunb.) Druce . . . . .	×								
<i>M. muricata</i> (L.) R. Br. . . . .	×		×		×				
<i>Relhania pungens</i> L'Herit. . . . .	×					×			
<i>Cineraria saxifraga</i> DC. . . . .									×
<i>Senecio angulatus</i> L.f. . . . .							×	×	
<i>S. brachypodus</i> DC. . . . .		×							
<i>S. burchellii</i> DC. . . . .					×				
<i>S. concolor</i> DC. . . . .	×		×		×		×		
<i>S. deltoideus</i> Less. . . . .						×			
<i>S. gramineus</i> Harv. . . . .	×								
<i>S. sp. cf. inaequidens</i> DC. . . . .			×						
<i>S. longifolius</i> L. . . . .	×			×		×		×	×
<i>S. othonnaeflorus</i> DC. . . . .	×								
<i>S. ?othonnaeflorus</i> DC. . . . .	×								

	AREAS								Nr W. Gate
	A	B	C	D	E	F	G	H	
<i>S. sp. cf. oxydontus</i> DC. . . . .							×	×	
<i>S. paniculatus</i> Berg. . . . .									×
<i>S. pterophorus</i> DC. . . . .	×		×						
<i>S. puberulus</i> DC. . . . .						×			
<i>S. radicans</i> (L.f.) Sch. Bip. . . . .								×	
<i>S. retrorsus</i> DC. . . . .			×	×	×	×	×		
<i>S. tropaeolifolius</i> MacOwan . . . . .	×								
<i>Chrysanthemoides monilifera</i> (L.) Norl. . . . .		×	×		×	×			
<i>Venidium decurrens</i> Less. . . . .				×					
<i>Haplocarpha lyrata</i> Harv. . . . .			×						
<i>Gazania linearis</i> (Thunb.) Druce . . . . .	×		×						
<i>Berkheya carduoides</i> (Less.) Hutch. ex Fourc. . . . .	×								
<i>B. decurrens</i> (Thunb.) Willd. . . . .	×								
<i>Oldenburgia arbuscula</i> DC. . . . .	×								
<i>Gerbera piloselloides</i> (L.) Cass. . . . .	×		×	×	×	×			
<i>Sonchus dregeanus</i> DC. . . . .	×				×				

(Species given as follows—(×)<sup>1</sup>—were recorded from the boundary of areas D and E.)

STUDIES IN THE XYLARIACEAE:  
VII. ANTHOSTOMELLA AND LOPADOSTOMA

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The genus *Anthostoma* was based on *A. decipiens* (DC) Nits. and placed in the Valsaceae by Nitschke (1897, p. 110) and divided into two sections, *Euanthostoma* and *Lopadostoma*. In both groups the stroma was considered to be immersed, but diatrypeoid or eutypelloid and effuse in the former and valsoid or restricted in the latter. The oval or cylindric rather than allantoid shape of the spores, however, was later recognized to be a xylariaceous character by Wehmeyer (1926), Petrak (1928), Miller (1928) and Shear (1938), and consideration of this character together with the development of a carbonaceous "clypeus" or rudimentary external stroma led to its eventual removal to the Xylariaceae by the two latter authors.

*Anthostoma* was not accepted as a clearly defined genus. In 1906 Traverso distributed the species of *Anthostoma* between *Lopadostoma*, which he raised to generic level, and *Anthostomella*, a further genus erected by Saccardo in 1877.

They were distinguished as follows:

*Anthostomella* Saccardo (1877): Stromata uniperitheciate to multiperitheciate, effuse rather than pulvinate.

*Lopadostoma* (Nitschke) Traverso (1906): Stromata multiperitheciate, erumpent, valsoid.

*Anthostoma* thus became redundant, though still containing species that were not transferred to either of the new groups.

*Structure of the stroma*

The stroma is immersed and simple in both genera since each contains little or no pure fungal tissue beneath the perithecia, although much of the wood may be invaded. The entostroma encloses most of the perithecial area, and varies from corky to carbonaceous in texture, showing little if any differentiation. The spores are oval to elliptic or cylindric but never elongate.

*Lopadostoma* and *Anthostomella* are best compared in the following important respects:



	<i>Lopadostoma</i>	<i>Anthostomella</i>
Character		
Ectostroma	Comprises fungal tissue together with the outer layer of the substrate (bark or wood) that is shed or retained at maturity. The part retained becomes fused with and indistinguishable from the entostroma beneath.  In <i>Lopadostoma</i> the ectostroma may be distinct ( <i>L. turgidum</i> ) but is usually discarded, so that stroma is erumpent and fully exposed at maturity.	In <i>Anthostomella</i> the ectostroma usually fuses with the carbonaceous entostroma; in some cases it is worn off to leave a somewhat truncate ostiolar apex.
Entostroma	Variable but characteristically massive, outer part forming a truncate cylinder ( <i>L. apiculatum</i> ) or pulvinate mass ( <i>L. turgidum</i> ).	Outer part typically apparent at maturity merely as a dull or shiny carbonaceous covering.
Ostioles	Tubular or not visible at stromal level, the former always produced above the perithecia and sometimes slightly curved or fluted.	Papillate, rarely tubular or indistinct; short and abrupt, rarely elongate; straight and smooth.
Asci	With flattened or discoid apical plug.	With cubic or oblong apical plug.
Spores	No appendiculate spores known.	Appendiculate spores frequent (section <i>Entosordaria</i> Sacc.).
Germ slits	Linear or poroid, on convex side of spore.	

On these grounds the two genera are recognized as distinct. *Lopadostoma* shows affinity with *Numulariola* but has less differentiation. *Anthostomella* is connected to *Hypoxyylon* (Entoleuca) through *A. uda* and also by *H. geasteroides* in which the woody ectostroma scales off before maturity.

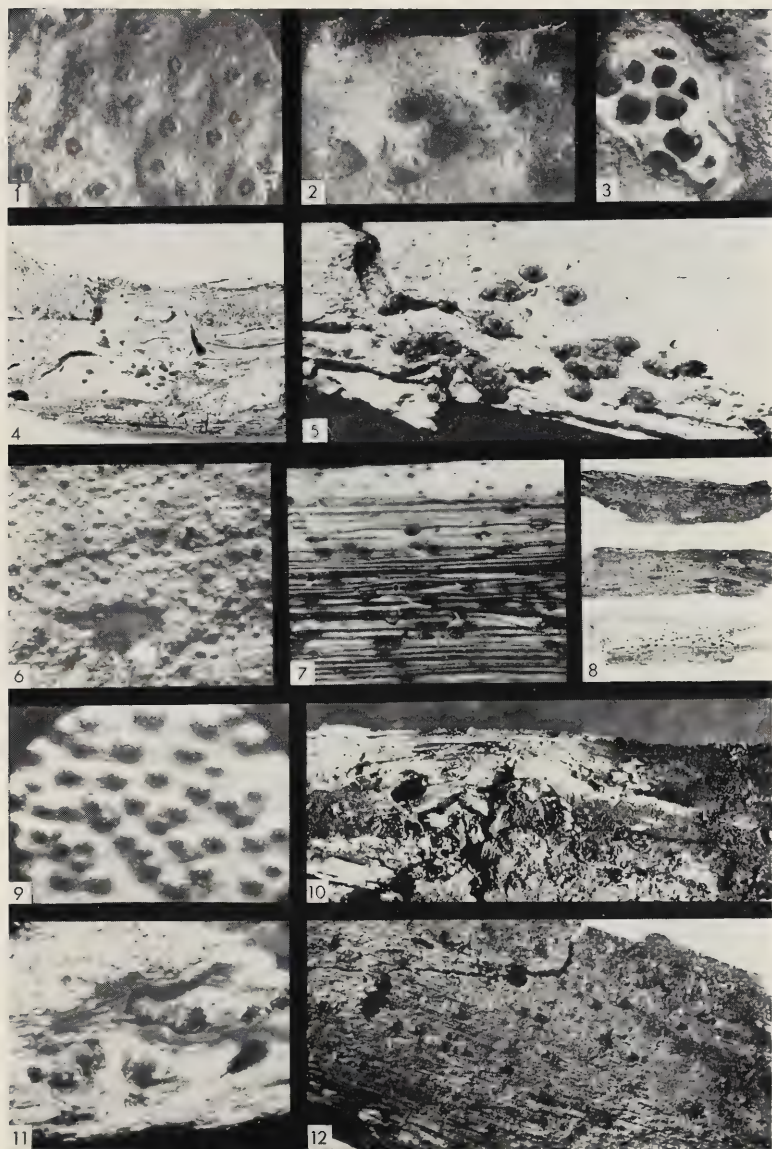
In the following keys several species have been reassigned according to the concepts of Saccardo and Traverso. The key covers those species in the New York Botanical Garden, and is representative but not complete. Until more information is available it is not considered wise to merge some species growing on monocotyledons with similar ones on dicotyledons, because there is some degree of host specialization apparent within these species.

### *Anthostomella*.

Stromata permanently immersed, uni- or multiperitheciate; irregularly globose, linear, pulvinate or aplanate, with ostioles projecting through the substrate that is often blackened or semi-carbonaceous; ascial plugs cubic or rectangular. Differs from *Hypoxyylon*: Entoleuca by immersion of stroma.

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PLATE I. Stromata. 1. *Lopadostoma turgidum*  $\times 1.25$ . 2. *Lopadostoma sphinctinum*  $\times 4$ . 3. *Lopadostoma juglandinum*: horizontal section of stroma showing valsoid structure of erumpent stroma  $\times 4$ . 4. *Anthostomella alpigena*  $\times 0.3$ . 5. The same:  $\times 2$ . 6. *Anthostomella flavoviride*  $\times 4$ . 7. *Anthostomella ludoviciana*  $\times 4$ . 8, 10, 12. *Anthostomella melanotes*. 8. Stromata  $\times 0.3$ . 10. Young innate stromata with conidiophores and mycelia  $\times 2$ . 12. Mature stromata, fully erumpent  $\times 2$ . 9. *Anthostomella nitidissima*  $\times 4$ . 11. *Anthostomella protuberans*  $\times 4$ .



1. Spores appendiculate  
.....(*Anthostomella*, sect. *Entosordaria* Sacc.).....2
- 1'. Spores not appendiculate.....10
2. Spores appendiculate on both ends.....3
- 2'. Spores appendiculate on one (proximal) end only.....4
3. Appendages obtuse, spores gibbous, broad-ended, medium to dark brown,  $8.5 \times 18.5\mu$ ; stromata mainly immersed.  
    *Anthostomella italica* (Sacc. & Speg.) Martin  
    syn. *Anthostoma italica* Saccardo & Spegazzini
- 3'. Appendages attenuate, spores navicular, narrow-ended, pale brown,  $5.5 \times 14.0\mu$ ; stromata evident in outline.
4. (2) Spores equilateral, dark brown.....5
- 4'. Spores inequilateral, pale brown.....9
5. On monocotyledonous hosts, including *Sabal*, spores narrow or broad-ended,  $5.0-5.5 \times 12.5-13.0\mu$ .  
    *Anthostomella sabalensioides* Ellis & Martin
- 5'. On dicotyledonous hosts.....6
6. Ostioles tubular, conspicuous or partly buried in the wood, spores narrow-ended,  $6.0 \times 14.0\mu$ ; wood often impregnated with white mycelium around the ostiole.  
    *Anthostomella albocincta* Ellis & Everhart
- 6'. Ostioles papillate, or not conspicuous.....7
7. Spores oval to subglobose, broad-ended,  $15.0 \times 22.0\mu$ .  
    *Anthostomella umbrinella* (DN.) Saccardo
- 7'. Spores elliptic.....8
8. Spores broad-ended,  $8.0-9.5 \times 20.0-20.5\mu$ ; stromata globose conic; perithecia evident with prominent papillate shiny ostioles.  
    *Anthostomella poetschii* Niessl
- 8'. Spores acute-ended,  $8.5-9.0 \times 23.5-26.0\mu$ ; stromata conic; perithecia vaguely evident; ostioles dull, surrounded by truncate collar of carbonous substrate.  
    *Anthostomella appendiculosa* (B. & Br.) Saccardo
9. (6) Spores gibbous, narrow-ended,  $3.5-5.0 \times 8.5-10.5\mu$ ; stromata minute, gregarious, globose, shiny.  
    *Anthostomella clypeata* (DN.) Saccardo
- 9'. Spores navicular, broad-ended,  $6.0 \times 13.0\mu$ ; stromata not aggregated, conic, dull.  
    *Anthostomella tomicoides* Saccardo
10. (1) Stromata minute, about  $50-100\mu$  diameter, substrate scarcely darkened.  
    (*Anthostomella*, section *Desciscentes* Saccardo).....11
- 10'. Stromata exceeding  $100\mu$  in diameter, substrate usually conspicuously darkened  
    (*Anthostomella*, sect. *Euanthostomella* Saccardo).....17
11. Spores globose to broad oval, equilateral.....12
- 11'. Spores oval to elliptic.....13
12. Spores dark brown,  $7.0 \times 10.0\mu$ ; on leaves  
    *Anthostomella pisana* (Pers.) Saccardo
- 12'. Spores black,  $13.0 \times 16.5\mu$ ; on stems  
    *Anthostomella coryphae* Rehm
13. (11) Spores equilateral, narrow-ended, pale brown  $4.5 \times 11.5\mu$ ; stromata pustulate or blisteriform.  
    *Anthostomella leucobasis* Ellis & Morgan
- 13'. Spores medium to dark brown; stromata otherwise.....14
14. Spores equilateral, dark brown.....15
- 14'. Spores gibbous to navicular, medium to dark brown.....16
15. Spores acute-ended,  $7.0 \times 13.0\mu$ ; stromata inconspicuous, not markedly gregarious.  
    *Anthostomella microsticta* Ellis & Everhart
- 15'. Spores broad-ended,  $5.5 \times 11.0\mu$ ; stromata gregarious with shiny black ostioles.  
    *Anthostomella palmicola* (Awd.) Rabenhorst
16. (14) Spores gibbous, narrow-ended, dark brown,  $8.0-8.8 \times 18.5-22.5\mu$ ; stromata gregarious but not shiny.  
    *Anthostomella melanosticta* Ellis & Everhart
- 16'. Spores gibbous to navicular, broad-ended, medium brown, with poroid germ slits,  $3.5-4.0 \times 6.5-9.0\mu$ ; stromata usually inconspicuous, sometimes a few adjacent but not generally gregarious.

- Anthostomella phaeosticta* (B. & Br.) Saccardo  
syn. *Anthostomella madeirensis* Petrak  
*Anthostomella pandani* (Rab.) Rehm.
17. (10) Stromata with one or a few perithecia, never taking the form of an indefinite crust; not containing more than 5 perithecia and rarely exceeding 4 mm long. . . . . 18
- 17'. Stromata with several perithecia united by a superficial carbonaceous crust or clearly gregarious; some stromata at least 3.5 mm long and/or containing 6 perithecia. . . . . 40
18. Spores equilateral, narrow-ended, colourless, hyaline, with thick transparent sheaths,  $15.5 \times 38.0 \mu$ .  
*Anthostomella rhizomorphae* (Kutz.) Berl. & Vogl. . . . . 19
- 18'. Spores with some degree of colouration. . . . . 19
19. Spores equilateral, broad-ended, dark brown with equatorial band paler than the peripheral areas,  $8.5 \times 16.0 \mu$ .  
*Anthostomella bicincta* Sydow . . . . . 20
- 19'. Spores concolorous. . . . . 20
20. Germ slits poroid at each end of spore; spores gibbous to broad crescentic, broad-ended, dark brown,  $11.0-12.0 \times 30.0 \mu$ .  
*Anthostomella uda* (Pers. ex Fr.) Martin nov. comb.  
*Hypoxylon udum* Persoon ex Fries . . . . . 21
- 20'. Germ slits straight linear. . . . . 21
21. Stromata with setose or subulate bases; spores equilateral, broad-ended, dark brown,  $10.0 \times 16.5 \mu$ .  
*Anthostomella mindorensis* Rehm . . . . . 22
- 21'. Stromata glabrous. . . . . 22
22. Stromata uniperitheciate, merely forming a circular area of darkened substrate around each ostiole; spores equilateral, broad-ended, pale brown,  $7.5 \times 16.0 \mu$ .  
*Anthostomella elmeri* Sydow . . . . . 22
- 22'. Stromata hemispherical, 1—3 peritheciate; exterior crust formed of stroma alone or with carbonized bark, often with shiny surface; spores equilateral, broad-ended, pale brown;  $13.0 \times 26.5 \mu$ .  
*Anthostomella calocarpa* Sydow . . . . . 22'
- 22' '. Stromata 1—3 peritheciate, raised into an exterior oval plaque around each ostiole; ostioles truncate due to splitting away of the bark; spores equilateral, narrow-ended, dark brown,  $6.0 \times 13.5 \mu$ .  
*Anthostomella discophora* Sydow . . . . . 23
23. External stroma around the ostioles not as above, irregular in outline or reduced. . . . . 23
- 23'. On monocotyledonous hosts. . . . . 24
- 23'. On dicotyledonous hosts. . . . . 30
24. Spores light brown. . . . . 25
- 24'. Spores medium brown to nearly black. . . . . 26
25. Spores equilateral, broad-ended, amber to pale brown,  $3.0 \times 6.0 \mu$ , conic, immersed or evident in outline; ostioles papillate but not conspicuous; on stems.  
*Anthostomella ludoviciana* Ellis & Langlois (Plate I:7) . . . . . 25'
- 25'. Spores navicular, narrow-ended, medium to dark brown,  $4.5 \times 11.5 \mu$ ; perithecia immersed completely though surrounded by black carbonized substrate; ostioles papillate; on leaves.  
*Anthostomella miscanthea* Saccardo . . . . . 27
26. (24) Spores equilateral. . . . . 27
- 26'. Spores inequilateral, gibbous. . . . . 29
27. Stromata rather small, 100—300  $\mu$  in diameter and immersed in the substrate; on *Yucca*, possibly specific for this. . . . . 28
- 27'. Stromata usually longer than 300  $\mu$  in diameter, and evident to some degree, sometimes like blisters; hosts various but not including *Yucca*; spores acute-ended, dark brown,  $6.0 \times 12.0 \mu$ .  
*Anthostomella contaminans* (D. & M.) Saccardo  
syn. *Anthostomella sepebilis* (B. & C.) Saccardo . . . . . 28
28. Spores broad-ended, dark brown,  $5.0 \times 9.0 \mu$ .  
*Anthostomella yuccae* von Thumen . . . . . 28'
- 28'. Spores broad-ended, dark brown to black,  $8.5 \times 17.0 \mu$ .  
*Anthostomella nigroannulata* Berkeley & Curtis . . . . . 28'



29. (26) Stromata immersed or evident in outline as conic protuberances; spores gibbous, narrow-ended, dark brown,  $7.5 \times 20.5 \mu$ .  
*Anthostomella tumulosa* (Rob.) Rabenhorst.
29. Stromata immersed, carbonization somewhat restricted or nearly absent; spores gibbous, broad-ended, medium to dark brown,  $9.5-10.0 \times 20.5-23.0 \mu$ .  
*Anthostomella lugubris* (Rob.) Saccardo  
 syn. *Anthostomella ammophila* Phil. & Plowright  
*Anthostomella calamagrostidis* Brun.
30. (23) Spores uniformly light brown ..... 31
- 30'. Spores medium to dark brown or varying from light to dark within the same sample ..... 33
31. Spores equilateral ..... 32
- 31'. Spores navicular to broad crescentic, narrow-ended,  $5.0 \times 13.0 \mu$ ; perithecia immersed completely, carbonized substrate minimal; ostioles tubular papillate and projecting from woody substrate.  
*Anthostomella protuberans* Martin nov. sp.
32. Spores equilateral, narrow-ended,  $3.5 \times 9.0-9.5 \mu$ ; perithecia immersed or vaguely evident, up to 10 in a flat crustose stroma; ostioles papillate, sometimes definitely sulcate.  
*Anthostomella inconspicua* Martin nov. comb.  
 syn. *Anthostoma picaceum* (C. & E.) Ellis & Everhart.
- 32'. Spores broad-ended,  $5.5 \times 20.0 \mu$ ; perithecia immersed, only ostioles visible as small dots surrounded by carbonized substrate.  
*Anthostomella cavarica* (Petrak) Martin  
 syn. *Anthostoma cavaricum* Petrak.
33. (30) Spores inequilateral, gibbous ..... 34
- 33'. Spores equilateral; or when slightly gibbous, stromata without prominent papillate ostioles ..... 35
34. Spores gibbous, broad-ended,  $5.5-6.0 \times 12.0-13.0 \mu$ ; perithecia immersed with only the ostioles evident, though wood strongly discoloured.  
*Anthostomella schmidtii* (Auersw.) Martin  
 syn. *Anthostoma schmidtii* (Auersw.) Nitschke
- 34'. Spores gibbous, broad to narrow-ended,  $7.0 \times 20.5 \mu$ .  
*Anthostomella helichrysi* Fabricius
35. Spores broadly oval to subglobose; stromata prominent with perithecia evident in outline ..... 36
- 35'. Spores elliptic; stromata not conspicuous if spores are somewhat broad in relation to length ..... 37
36. Spores broad-ended,  $6.5 \times 10.5 \mu$ .  
*Anthostomella vaga* Niessl
- 36'. Spores broad-ended,  $7.5-10.0 \times 13.5-14.5 \mu$ .  
*Anthostomella alpigena* (Fckl.) Martin  
 syn. *Anthostoma alpigenum* (Fckl.) Saccardo
37. (35) Spores narrow-ended,  $5.5-9.0 \times 10.5-16.0 \mu$ ; stromata minute to small, uniperitheciate, immersed except for minute projecting ostioles or perithecial vertices clearly evident, conical.  
*Anthostomella melanotes* (B. & Br.) Martin  
 syn. *Anthostoma melanotes* (B. & Br.) Saccardo
- 37'. Spores broad-ended, or if narrow then much longer ..... 38
38. Spores  $6.0 \times 12.5 \mu$ ; stromata 1-4 peritheciate, distinct, ostioles usually strongly papillate.  
*Anthostomella ostiolata* Ellis & Everhart
- 38'. Spores  $6.0 \times 12.0 \mu$ ; stromata uniperitheciate, mostly immersed; ostioles shiny, conic, tubular to inconspicuous.  
*Anthostomella eructans* Ellis & Everhart
- 38''. Spores larger ..... 39
39. Stromata small with variable degree of immersion, carbonized substrate minimal to pronounced, spores broad or narrow-ended,  $6.5-9.5 \times 13.0-16.5 \mu$ .  
*Anthostomella xylostei* Saccardo  
 syn. *Anthostoma mortuosa* Ellis
- 39'. Stromata small but shiny; spores larger, broad-ended,  $7.5-10.5 \times 19.0-22.5 \mu$ .



- Anthostomella sustenta* (Plow.) Martin  
syn. *Anthostoma sustentum* (Plow.) Saccardo
40. (17) Spores hyaline, almost colourless, cylindric, broad-ended,  $7.5 \times 14.0 \mu$ .  
*Anthostomella ratibidae* Solheim
- 40'. Spores some distinct shade of brown. . . . . 41  
41. Perithecia clearly evident in outline. . . . . 42  
41'. Perithecia completely immersed in the stroma. . . . . 44  
42. Spores equilateral to gibbous, broad-ended, dark brown,  $9.5 \times 19.0 \mu$ ; stromata free of substrate at maturity, somewhat shiny.  
*Anthostomella hypsophila* Ellis & Everhart
- 42'. Spores narrow-ended, smaller; stromata at least partially covered by substrate. . 43  
43. Spores gibbous to navicular, narrow-ended, dark brown,  $5.0-8.0 \times 13.0-15.5 \mu$ ; carbonous matrix sometimes shiny.  
*Anthostomella tomicum* (Lév) Saccardo  
syn. *Anthostomella lucens* Saccardo
- 43'. Spores gibbous to navicular, narrow-ended, pale to dark brown,  $3.5-4.0 \times 7.5-8.5 \mu$ ; carbonous matrix dull; ostioles often annulate after removal of substrate.  
*Anthostomella nitidissima* (D. & M.) Saccardo (Plate I:9)  
syn. *Anthostomella cocoina* Sydow  
*Anthostomella minor* Ellis & Everhart  
*Anthostomella sacchariferae* Rehm
- 43''. Spores equilateral to gibbous, narrow-ended, amber to pale brown,  $6.0 \times 14.5 \mu$ ; stromata immersed though evident in outline, dull.  
*Anthostomella sphaerotheca* Earle
44. (41) Stromal surface black, spores navicular, crescentic to allantoid, narrow-ended, pale brown,  $4.0 \times 10.5 \mu$ .  
*Anthostomella picacea* Saccardo
- 44'. Stromal surface faint olive green, granulate; spores equilateral, narrow-ended, medium brown,  $4.5 \times 11.0 \mu$ .  
*Anthostomella flavoviride* (E. & H.) Martin (Plate I:6)  
syn. *Anthostoma flavoviride* Ellis & Holway.

*Lopadostoma.*

Stroma innate but irregularly erumpent, valsoid, circular, linear or pulvinate; perithecia several, close packed, often with long necks; ostioles sessile to tubular; substrate not conspicuously altered by fungus; ascus plugs discoid or flattened. Differs from *Numulariola* in vestigial ectostroma and smaller size.

1. Ostiolar mouths white, sometimes also surrounded by a white mycelial invasion of the wood; ostioles smooth and tubular in form. . . . . 2
2. Ostiolar mouths black, without trace of white mycelium; ostioles smooth or sulcate, beaked, tubular or sessile. . . . . 3
2. Spores equilateral, broad-ended, medium to dark brown,  $9.5 \times 15.5 \mu$ .  
*Lopadostoma cubiculare* (Fr.) Martin  
syn. *Anthostoma cubiculare* (Fr.) Nitschke
- 2'. Spores equilateral, acute-ended, dark brown,  $11.0 \times 17.5 \mu$ .  
*Lopadostoma stictoides* (E. & E.) Martin  
syn. *Anthostoma stictoides* Ellis & Everhart
- 2''. Spores equilateral to gibbous, acute-ended, medium to dark brown,  $11.0 \times 27.5 \mu$ .  
*Lopadostoma ostropoides* (Rehm) Martin  
syn. *Anthostoma ostropoides* Rehm
3. (1) Ostioles beaked and very conspicuous; stromata often in linear groups. . . . . 4
- 3'. Ostioles sessile to tubular but rarely conspicuous. . . . . 6
4. Ostioles sulcate, similar to those of *Diatrype*; spores equilateral, broad-ended, pale to medium brown,  $3.5 \times 7.5 \mu$ .  
*Lopadostoma decipiens* (DC.) Martin  
syn. *Anthostoma decipiens* (DC.) Nitschke
- 4'. Ostioles entire, not divided. . . . . 5
5. Spores equilateral, broad-ended, medium to chestnut brown,  $8.5-9.5 \times 19.0-23.5 \mu$ .

- Lopadostoma apiculatum* (Currey) Martin  
syn. *Anthostoma apiculatum* (Currey) Nitschke
- 5'. Spores equilateral, broad-ended, medium to dark brown,  $4.0 \times 11.0 \mu$ .  
*Lopadostoma formosum* (E. & E.) Martin  
syn. *Anthostoma formosum* Ellis & Everhart
6. (3) Stromata forming a conspicuous erumpent shallow concave to pulvinate, circular to oblong crust (clypeus) above the perithecia. ....12
- 6'. Stromal material not greatly developed above the perithecia; stromata circular (hypoxylod) or linear (diatrypeoid) .....7
7. Stromata circular (hypoxylod) .....8
- 7'. Stromata linear (diatrypeoid) appearing through cracks in the substrate. ....9
8. Stromata with several narrow perithecia packed as in *Numulariola*; ostioles sessile, indistinct; spores cylindric or clearly so, amber, subhyaline,  $2.5 \times 5.0-5.5 \mu$ .  
*Lopadostoma microsporum* (Karst.) Martin  
syn. *Anthostoma microsporum* Karsten
- 8'. Stromata 1-2 peritheciate; ostioles indistinct papillate; spores broad oval, equilateral, medium brown,  $6.0 \times 9.0 \mu$ .  
*Lopadostoma conorum* (Fckl.) Martin  
syn. *Anthostoma conorum* (Fckl.) Saccardo  
*Anthostomella pholidigena* Ellis
9. (7) Spores amber, hyaline, equilateral, elliptic to cylindric, broad-ended,  $3.0 \times 5.0 \mu$ ; perithecia large, 700-800  $\mu$  in diameter, usually grouped in linear or crescentic pattern.  
*Lopadostoma helvetica* (Fckl.) Martin  
syn. *Anthostoma helvetica* Fuckel
- 9'. Spores pale brown or darker, translucent to opaque .....10
10. Spores fusoid, narrow or acute-ended, medium to dark brown,  $9.5 \times 22.0 \mu$ .  
*Lopadostoma rhenanum* (Fckl.) Martin  
syn. *Anthostoma rhenanum* (Fckl.) Rabenhorst
- 10'. Spores broad-ended .....11
11. Spores equilateral, dark brown,  $3.5 \times 6.5 \mu$ .  
*Lopadostoma microecium* (E. & E.) Martin  
syn. *Anthostoma microecium* Ellis & Everhart
- 11'. Spores equilateral, medium brown,  $4.0 \times 9.0-9.5 \mu$ .  
*Lopadostoma juglandinum* (Rehm) Martin (Plate I:3)  
syn. *Anthostoma juglandinum* Rehm
- 11''. Spores equilateral, dark brown,  $7.5 \times 13.0 \mu$ .  
*Lopadostoma caespitosum* (E. & E.) Martin  
syn. *Rosellinia caespitosa* Ellis & Everhart
12. (6) Clypeus irregular in form, at the same time level as the bark or slightly concave beneath it; spores equilateral, broad-ended, dark brown,  $3.5 \times 9.0-5.5 \times 10.0 \mu$ .  
*Lopadostoma turgidum* (Pers.) Traverso (Plate I:1)
- 12'. Clypeus convex, pulvinate or hemispheric, usually raised above the substrate level .....13
13. Clypeus usually hemispheric though sometimes pulvinate, ostioles conic to indistinct; spores  $3.5-4.0 \times 9.0-9.5 \mu$ .  
*Lopadostoma sphinctinum* (Fr.) Martin (Plate I:2)  
syn. *Anthostoma sphinctina* (Fr.) Saccardo  
*Anthostoma dryophilum* (Curr.) Saccardo
- 13'. Clypeus pulvinate, ostioles characteristically tubular though sometimes very short; spores equilateral, narrow-ended, medium brown,  $3.5-5.0 \times 10.0-11.0 \mu$ .  
*Lopadostoma gastrinum* (Fr.) Traverso

### Species Description:

It is unfortunate that only a few species of *Anthostomella* and no species at all of *Lopadostoma* were able to be cultured. The species of *Anthostomella* are interesting however in that they relate well with the section *Entoleuca* of *Hypoxylon*, in regard to their conidiophores.

1. ***Anthostomella melanotes*** Saccardo. (Fig. I:2, Plate I:8, 10, 12, Plate III:1—3)

Ellis J. B. & B. M. Everhart Jour. Mycol. 3, 44, (1887); N. Amer. Pyren. 48, (1892).  
Traverso J. B. Flora Ital. Crypt. I, 176, (1906).

Stromata aplanate on decorticated wood with the major part immersed in the substrate, discoid to oval,  $0.3\text{--}0.8 \times 0.3\text{--}2.4 \times 0.3\text{--}1.1$  mm. Ectostroma mixed with wood and not discernible at maturity; outer entostroma carbonaceous, superficial, surrounding apices of perithecia; basal tissue not well developed and not extending far beyond the perithecial bases; host wood not infected by mycelium to any marked degree. Perithecia 1–3 per stroma, globose to coniform,  $200\text{--}700 \times 200\text{--}1,000\mu$ ; ostioles medium papillate. Asci clavate, long stipitate,  $120\text{--}130 \times 9\mu$ ; stipes  $70\text{--}75\mu$ . Spores oval, equilateral to gibbous, with prominent gelatinous sheaths, light to dark brown,  $4.5\text{--}9.5 \times 8.0\text{--}16.5\mu$ , ave.  $6.7 \times 12.9\mu$ .

South African hosts: *Canthium spinosum* and wood unidentified.

*Material examined*:—

Martin 12, 75, 103, 147, 149, 349, 429, 432, 436, 536, 568, 569, 570, 572; Nature's Valley, Knysna District, Western Cape, South Africa (1958, 1959). Mason in Herb IMI 45311; on *Ulmus*, Rewell wood, Arundel, England, (1939), (NYBG).

*Cultural characters* (Plate II:3—4):

Colonies mainly velvety, sometimes velvet felty but with smooth surface, forming a closely appressed mat on the agar surface. Growth is uniform or zonate, 6 zones each 3 mm wide and 7 mm apart being formed in 4 weeks at  $20\text{--}25^\circ\text{C}$ . After 2 months in bottle culture, scattered floccose dull white to pale grey outgrowths are formed which are similar to those of *A. alpigena*, and the initial zonate pattern is obscured. Margin not distinct, entire, compact hyphae lying closely parallel. Conidia appear after 7 days as a thin white fawn or very pale grey covering over the centre of the colony. Stain and carbonization absent. Growth rate slow,  $0.6$  mm/day at  $25^\circ\text{C}$ . Growth on other media similar except on Czapek where growth is uniform, submersed initially and later canescent.

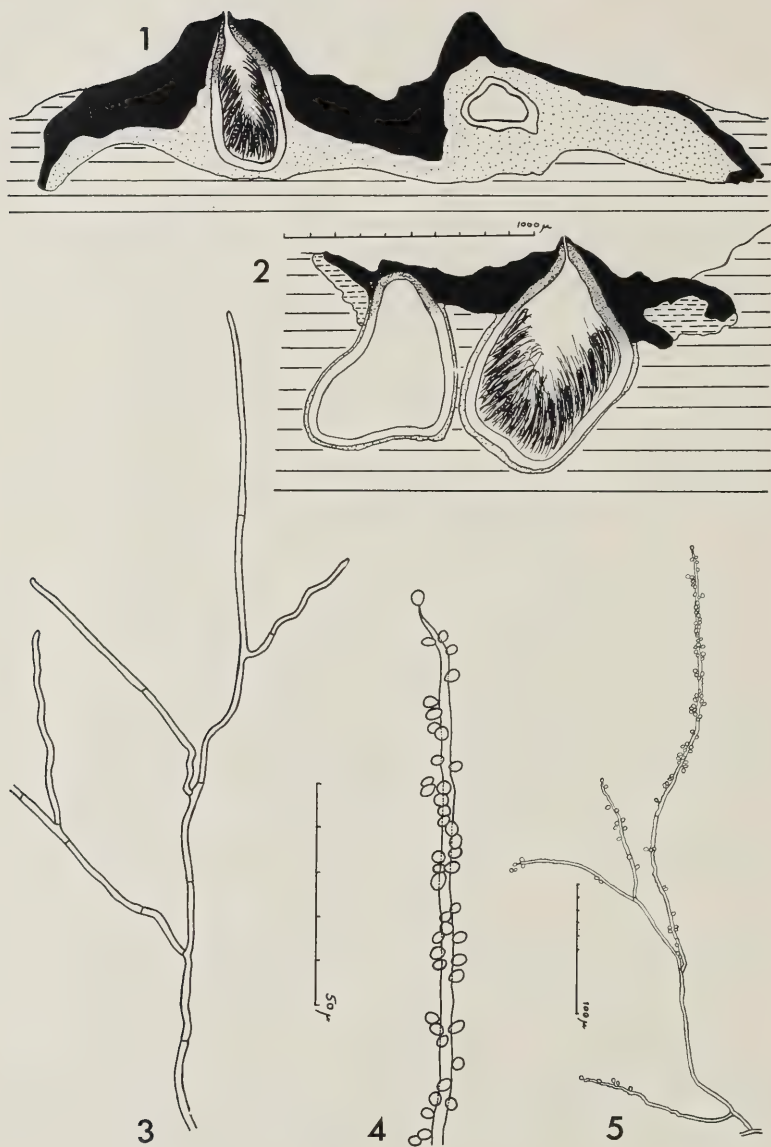
*Microscopic characters*:

Primary mycelium undiagnostic; marginal hyphae rather narrow, up to  $1.7$  mm in diameter. Secondary mycelium absent.

Imperfect stage (Plate III:4). See also Martin (1967), p. 226, fig., 4.

Traverso J. B. Flora Ital. Crypt. I, 172, (1906).

The conidiophores and conidia correspond to the *Nodulisporium* type IIa, comprising long indefinite systems with dichotomous branching,  $300\text{--}500 \times$



1.5—2.0 $\mu$ . Fertile branches are geniculate, lying freely, usually nonseptate but with up to 2 septae; 85—100 $\times$ 1.5—2.0 $\mu$ . The upper 9—20 $\mu$  of the fertile branches bear conidia in dense spicate clusters, each conidium on a wart like prominence. The conidia are subglobose to oval with wide truncate bases, pale fawn grey en masse, 1.4—2.6 $\times$ 2.3—4.0 $\mu$ , ave 1.8 $\times$ 3.0 $\mu$ .

2. *Anthostomella alpigena* (Fckl.) Martin nov. comb. (Fig. I:1, Plate I:4, 5).

sub *Amphisphaeria alpigena* Fuckel.

Fuckel L. Symb. Myc. Nachtrag I, 16, (1871).

sub *Anthostoma alpigenum* (Fckl.) Sacc.

Bizzozero G. Flora veneta critt. 1, 196, (1885); Rabenhorst L. Kryptogamenflora II, 755, (1887). Saccardo P.A. Atti. Soc. Ven. Trent. 4, 95, (1875); Fungi Italici 161, (1877—1886); Syll. Fung. I, 301, (1882). Traverso J. B. Flora Ital. Crypt. I, 178. (1906).

Stromata aplanate on decorticated wood, with a clearly defined orbicular or linear carbonized entostromal area surrounding each characteristically conic perithecial vertex; 2.0—5.6 $\times$ 4.0—12.0 $\times$ 0.7—0.8 mm. Perithecia 1—3 per stroma, 200—300 $\times$ 600—700 $\mu$ ; ostioles papillate. Asci clavate, 110—150 $\times$ 6—10 $\mu$ . Spores broadly oval to subglobose, dark brown, 4.5—10.0 $\times$ 9.0—19.5 $\mu$ ; ave 8.9 $\times$ 13.8 $\mu$ .

South African hosts: *Acacia cyclops*, *Sideroxylon inerme*.

Material examined:—

sub *Anthostoma alpigenum*

Berlese in Saccardo's Mycotheca Italica 1289; on *Lonicera caprifolia*, Sassari, Sardinia, (1901). (NYBG). Gelbenegger 1722; on *Lonicera xylostei*, Ybbsitz, Austria, (date ?), (NYBG).

sub *Anthostoma mortuosa*

Ellis on *Polygonum*, Newfield, N.J., U.S.A., (1888), (NYBG).

sub *Anthostomella alpigena*

Martin 257, 529; Kenton-on-Sea, Eastern Cape, South Africa, (1958, 1959). Martin 1004; Nature's Valley, Knysna District, Western Cape, South Africa, (1962).

Cultural characters (Plate II:1—2, 5—9):—

Colonies at first coarse felty with dense white aerial mycelium up to 0.3 mm high, later floccose with a coarse surface and developing grey flaring sterile mycelial aggregates 2—15 mm long, near the original point of inoculation or scattered over most of the colony. The aerial mycelium is white, sometimes turning very pale cream or orange with age. Growth is uniform in plate culture but zonate inside bottles, 6 zones 3 mm wide developing by a month. With age

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FIG. I. 1—2. Vertical sections through Stroma. Solid black: carbonous entostroma. Fine lines: carbonized perithecial wall. Blank: soft perithecial wall. Stippling: corky basal tissue. Interrupted lines: fungal invasion of wood. Solid lines: host wood. 1. *Anthostomella alpigena*. 2. *Anthostomella melanotes*. 3—5. *Anthostomella alpigena*: microscopic characters. 3. Marginal hypha. 4. *Nodulisporium* type I conidiophore: detail of fertile branch. 5. The same: whole conidiophore.



a distinct rind 1.5 mm thick is formed in the substrate but there is no carbonization. The margin is distinct, submersed, 2—3 mm broad, usually uneven and segmented due to compact or effuse growth of the hyphae in different directions. Conidia are produced with age, after 6 months in bottle culture, very finely granulate and pale fawn in colour. Stain appears after 2—3 weeks, faint ochre yellow and diffuse throughout the substrate, also exuded as droplets on the mycelial surface. Growth is slow, 1.9 mm/day at 25°C.

Growth on other media is similar but much less luxuriant on Czapek.

*Microscopic characters* (Fig. 1:3):—

Primary mycelium rather narrow, marginal hyphae with a maximum diameter of 1.7 $\mu$ . Secondary mycelium absent.

*Conidiophores and conidia* (Fig. 1:4, 5):—

This species has one of the least specialized types of conidiophore so far observed in the Xylariaceae, corresponding to *Nodulisporium* type I. They are scarcely distinct from the vegetative mycelium but are extremely long, 500—700  $\times$  2.0—2.5 $\mu$ , dichotomously branched to the second degree or indefinitely. Fertile branches irregular in outline but not definitely geniculate, 96—340  $\times$  2.0—2.5 $\mu$ . Conidia produced apparently at random from all over the axes, either simply or in groups of 2—3, sessile, oval to subglobose with narrow bases, tinted pale yellow or fawn en masse, 1.7—3.2  $\times$  2.6—3.4 $\mu$ , ave. 2.4  $\times$  3.2 $\mu$ .

### 3. *Anthostomella xylostei* (Saccardo) Martin nov. comb.

sub *Anthostoma mortuosa* Ellis J. B. Bull. Torrey Bot. Club **9**, 73, (1882).

sub *Anthostoma xylostei* Saccardo

Bizzozero G. Flora veneta critt. **1**, 196, (1885). Dennis R.W.G. British Cup Fungi 176, (1960). Kickx J. Recherches à la flore crypt. de Flanders **V**, 19, (1885). Rabenhorst L. Krypt. flor. Deutsch. **II**, 755, (1887). Rehm. H. Berichte Naturh. Vereins Augsburg. **26**, 14, (1881). Saccardo P.A. Fungi Ital. 162, (1877—1886); Syll. Fung. **I**, 300, (1882). Schroter J. in Cohn: Kryptoflor. Schlesien 433, (1908). Starbäck K. Bih. Svenska Vet. akad. Handl. **15**, 8, (1889). Strassen P. Ann. Mycol. **9**, 91, (1911). Traverso J. B. Flora Ital. Crypt. **I**, 177, 1906.

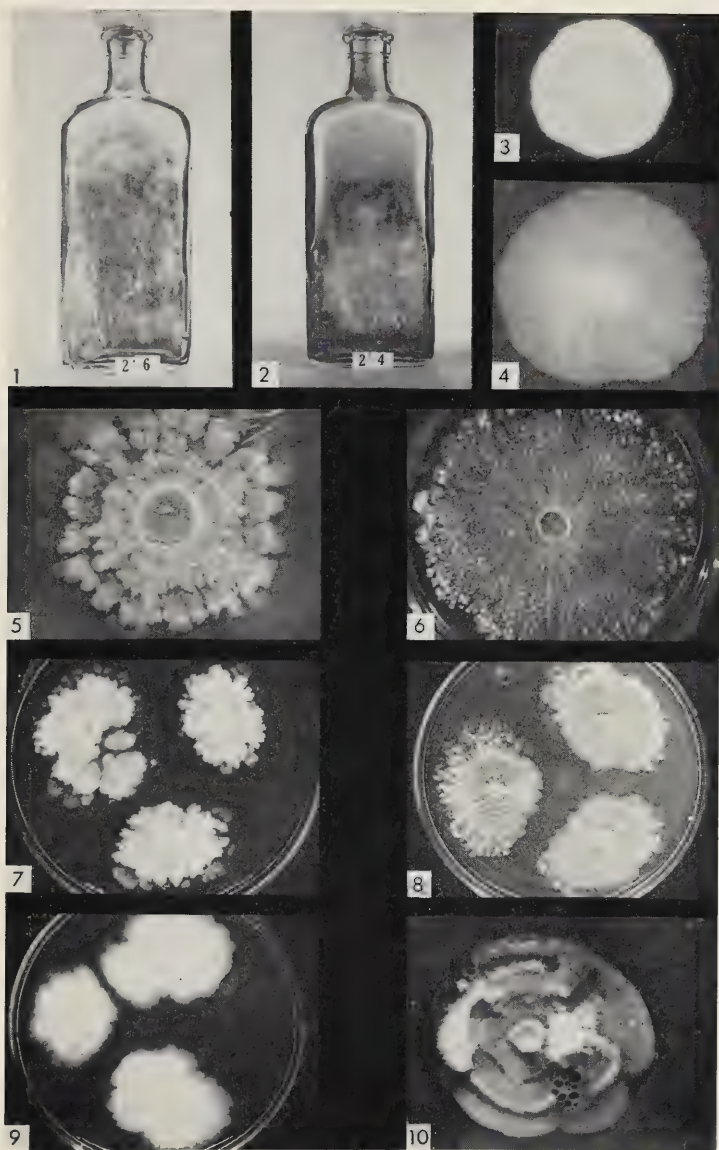
sub *Sphaeropsis xylostei* Petrak. & Sydow.

Petrak F. & H. Sydow. Ann. Mycol. **22**, 335, (1924).

Stromata globose, discoid or irregular, with up to 5 perithecia, 0.5—1.0  $\times$  0.6—2.8  $\times$  0.7—0.9 mm. Ectostroma not apparent, entostroma similar to but

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PLATE II. Cultural characters. All 14 days old at 25°C unless otherwise stated. 1—2. *Anthostomella alpigena*; bottle cultures. 1. Malt agar. 2. Leonian's agar. 3—4. *Anthostomella melanotes*; plate cultures. 3. Malt agar. 4. Maize agar. 5—9. *Anthostomella alpigena*; plate cultures. 5, 6. Malt agar, 14 and 28 days old. 7. Leonian's agar. 8. Maize agar. 9. Czapek agar. 10. *Anthostomella sabalensioides*; malt plate.



more restricted in quantity than in *A. alpigena*, comprising a small carbonized area around each ostiole and a scant degree of dull brown to black corky basal tissue. Perithecia evident at vertices to completely immersed, globose, sometimes with conic vertices,  $400-700 \times 600-800 \mu$ ; ostioles tubular or medium papillate. Asci cylindric,  $130-190 \times 8-16 \mu$ ; stipes  $10-90 \mu$ . Spores broad oval to elliptic, equilateral to gibbous, with broad or narrow ends, dark brown brown,  $6.0-11.5 \times 11.0-19.0 \mu$ , ave.  $8.4 \times 14.6 \mu$ .

*Material examined*:—

sub *Anthostoma mortuosa*

Ellis ?; on *Vitis*, Newfield, N.Y., U.S.A., (1882), (NYBG). Ellis N. Amer. Fungi 897; on *Eupatorium* and *Andropogon*; Newfield, N.J., U.S.A., (NYBG).

sub *Anthostoma xylostei*

Allescher & Schnabl's Fungi bavarici 251; on *Lonicera nigra*, Oberammergau, Germany, (1892), (NYBG). Desmazières 1768; on *Lonicera xylostei* (? details), (NYBG). Fautrey in Roumeguère's Fungi selecti exsicc. 6102; on *Lonicera periclymenum*, Côté d'Or, France, (1892), (NYBG). Rehm's Ascomyceten 41B; on *Lonicera xylosteum*, Oberbayern, Germany, (1908), (NYBG).

sub *Anthostomella xylostei*.

Martin 585; Fernkloof, Grahamstown, E. Cape, South Africa, (1960). Martin 758, 761; O'Brien, N. Calif., U.S.A., (1961).

*Cultural characters*:—

Colonies felty, uniform, growing freely with fine texture, pure white; mycelial aggregates absent. Margin not distinct, entire, hyphae lying together. Conidia formed when old, not conspicuous. Stain and carbonization absent. Growth rate slow,  $1.8 \text{ mm/day}$  at  $25^\circ\text{C}$ .

*Microscopic characters*:—

Primary mycelium narrow; maximum diameter of the marginal hyphae =  $1.5 \mu$ . Secondary mycelium absent.

*Conidiophores and conidia* (Plate III:5, 8):—

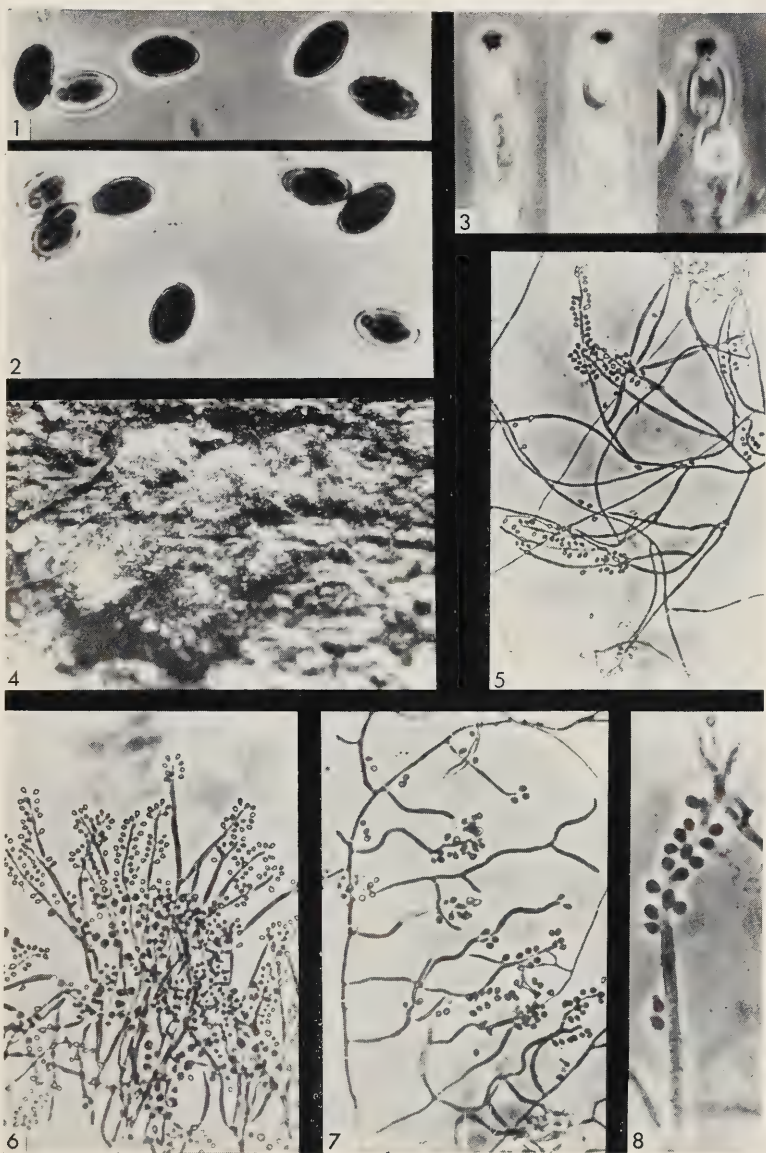
Conidiophores similar to those of *A. alpigena* in indefinite dichotomous branching but more clearly distinct on account of shorter length and geniculate fertile branches (*Nodulisporium* IIa);  $180-240 \times 1.2-1.3 \mu$ . Fertile branches lying freely,  $37-120 \times 1.2-1.3 \mu$ . Conidia pleuracrogenous or arising all over the axes, sessile, broad clavate, pale grey en masse,  $1.8-1.9 \times 2.5-3.1 \mu$ , ave.  $1.9 \times 2.8 \mu$ .

PLATE III. Microscopic characters.

1—4. *Anthostomella melanotes*. 1, 2. Spores with linear germ slits and prominent gelatinous sheaths, latter disintegrating in some cases.  $\times 675$ . 3. Young asci with cubical ascal plugs. Iodine stain.  $\times 675$ . 4. Surface view of prominent conidial mats on wood and on ostiolar mouths.  $\times 12.5$ .

5, 8. *Anthostomella xylostei*. 5. Conidiophores.  $\times 270$ . 8. Detail of above.  $\times 675$ .

6, 7. *Anthostomella protuberans*. Compact and dendroid conidiophores.  $\times 270$ .





**4. *Anthostomella protuberans* Martin nov. sp. (Plate I:11)**

Stromata in ligno mortuo; perithecia innata, solum ostiola cylindrica extantes; sporae navicularae, pallidae fuscae, medius  $4.9 \times 12.9\mu$ .

Stromata globose to discoid or irregular, with up to 4 perithecia,  $1.1-1.2 \times 1.2-3.0 \times 1.6$  mm. Ectostroma and carbonous entostroma very slightly developed, dull brown, leaving the ostioles as virtually the only part of the stroma above substrate level, basal tissue slight, black. Perithecia vaguely evident to completely immersed, globose to oval, rather large,  $1,100-1,500 \times 1,500-1,700\mu$ ; ostioles elongate, distinctly tubular and conspicuous in side-view. Asci not seen. Spores navicular to crescentic, ends narrow rounded, pale brown, with prominent sheaths  $3.5-5.5 \times 11.0-14.5\mu$ , ave.  $4.9 \times 12.9\mu$ .

*Material examined*:—

Martin 1174; Lake Ozark, Mo., U.S.A., (1962).

*Cultural characters*:—

Colonies canescent, appressed, uniform, colourless to white sub-hyaline, without mycelial aggregates. Margin not distinct, entire; hyphae lying compactly. Conidia formed immediately as in *Hypoxylon serpens* and *H. ludovicianum* (*Hypoxylon* section *Entoleuca*). Stain and carbonization absent. Growth rate exceedingly slow, 0.1 mm/day at 25°C.

*Microscopic characters*:—

Primary mycelium narrow, undiagnostic; maximum diameter of marginal hyphae =  $1.2\mu$ . Secondary mycelium absent.

*Conidiophores and conidia* (Plate III:6, 7):

Conidiophores corresponding to *Nodulisporium* type IIa; similar to the vegetative mycelium,  $90-230 \times 1.2-1.5\mu$ , dichotomously branched distally to the first or second degree. Fertile branches irregular to regularly geniculate, lying freely,  $18-67 \times 1.8-2.5\mu$ . Conidia pleuracrogenous, not borne randomly, sessile, subglobose, broad based, fawn brown en masse,  $1.8-3.7 \times 2.7-3.7\mu$ , ave.  $2.8 \times 3.4\mu$ .

**5. *Anthostomella sabalensioides* Ellis & Martin**

Ellis J. B. Amer. Nat. 16, 810 (1882). Ellis J. B. & B. M. Everhart N. Amer. Pyren. 421, (1892).

Stromata discoid to irregular, evident externally as a carbonaceous matrix with up to 6 perithecia,  $0.3-1.5 \times 0.3-5.0 \times 0.3-0.5$  mm. Ectostroma scanty, submersed in wood. Entostroma slight; outer part carbonaceous, black, basal tissue corky, dull brown to black. Perithecia vaguely evident to immersed,



oval,  $300-400 \times 400-600\mu$ ; ostioles short, medium papillate or indistinct. Asci cylindric,  $75-115 \times 7-10\mu$ ; stipes very short,  $7-18\mu$ . Spores elliptic, each with a short obtuse appendage on the proximal end; other end broad or narrow; dark brown,  $3.5-7.5 \times 10.5-15.5\mu$ , ave.  $5.2 \times 13.0\mu$ .

Hosts: Apparently restricted to woody monocotyledons, including *Sabal*.

*Material examined:—*

Calkins in Ellis & Everhart's North Amer. Fungi 1964; on *Sabal serrulata*, Florida, U.S.A., (1887), (NYBG). Martin 1750 ex Carroll 90; on *Smilax*, Quetzaltenango, Guatemala, (1962). Martin 1804 ex Carroll 577; Rivercrest, Austin, Texas, U.S.A., (1963).

*Cultural characters* (Plate II:10):—

Colonies felty to floccose, pure white, dry to gelatinous in aspect, growing freely with fine texture. Mycelial aggregates absent. Growth is partly zonate with 1 or 2 zones developed in each colony. Margin distinct, narrow but distinctly lobed; hyphae compact. Conidia produced when old and not conspicuous. Stain and carbonization absent. Growth rate very slow,  $0.7$  mm/day at  $25^{\circ}\text{C}$ .

*Microscopic characters:—*

Primary mycelium not diagnostic; maximum diameter of marginal hyphae =  $1.8\mu$ . Secondary mycelium absent.

*Conidiophores and conidia:—sterile.*

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## BOOK REVIEWS

**PLANT SYMBIOSIS** BY GEORGE D. SCOTT. The Institute of Biology's Studies in Biology No. 16. Edward Arnold (Publishers) Ltd., London. 1969. 58 pp. figs. 15 + 6 plates. 14s. (U.K.)

This book opens with a most valuable and clear statement of the nature of symbiosis, followed by a thought-provoking discussion of the possible origin of symbiotic associations. The morphological aspects of a very wide range of symbiotic systems, many of which may hitherto be unfamiliar to the non-specialist reader, are then described. Particular mention should be made of the masterly summary of the biology of lichens, as well as the concise and up to date description of mycorrhiza and nitrogen-fixing nodules. One of the most useful features of the book is the analysis of physiological integration which occupies chapter 4. Throughout, the emphasis is on general physiological principles, although with adequate reference to named examples. In this, and especially in the final chapter, the broader implications with respect to evolution, ecology and possible utilisation are kept well to the fore.

*Plant Symbiosis* can be unreservedly recommended. Nowhere else is this topic discussed in such a comprehensive yet attractive and easily digestible form. This book is of particular interest to readers in Southern Africa insofar as Dr. George Scott is a member of the Botany Department of the University College of Rhodesia, Salisbury, and makes several references to examples drawn from the region. Moreover this book provides a stimulus to the further study of our own symbionts, which whether from a systematic, ecological or physiological point of view, have been woefully neglected.

A. R. A. NOEL

**DEVELOPMENTAL PLANT ANATOMY** BY ALAN R. GEMMELL. The Institute of Biology's Studies in Biology No. 15. Edward Arnold (Publishers) Ltd., London, 1969. 60 pp. figs. 25 + 12 plates. 14s (U.K.)

The series, sponsored by the Biological Education Committee set up by the Royal Society and the Institute of Biology, is intended to deal with "topics in which recent progress has been most rapid and important" and to enable students to "be contemporary in their biological outlook". This book does neither. It is in fact a highly condensed course in elementary anatomy, with conventional subject treatment which does not come up to the standard of that in many currently available textbooks of general botany.

Because of its low price and outwardly attractive format, this book will undoubtedly fall into the hands of students and for this reason it is necessary to point out some of the inaccuracies and examples of gross carelessness which abound on nearly every page. Thus we have "lignin thickening", "border pits", "annular protoxylem", "dicot. leaf" and in figure 3-1, in which a vascular bundle is illustrated, "A rough diagram of part of a trans-section of sunflower". The general standard of photomicrographs and line drawings, and their captions, is very low. Figure 2-2, a "diagram of longisection of top of procambial strand" and figure 4-2, of the vascular cambium and its products, will certainly mislead students. The vermiform object in figure 5-3 is labelled a "tracheid or xylem fibre"!

A most ambiguous discussion on the first page might lead the reader to suppose that the mycelium of *Mucor* consisted of a chain of cells, and the advisability of referring to the hyphal tip as a meristem may be disputed. We are told that "it is not easy to see definite apical cells and in consequence descriptions of the plant apex have fallen into three main categories". The account which follows, which includes a discussion of the histogen theory, is confusing in a book at this level, especially as it leads to the statement that the epidermis is derived from "the outermost layer of the tunica, or the dermatogen, or the protoderm or the mantle layer". There is an unnecessarily long and obscure discourse on the arithmetical complexities of phyllotaxy, which is not well integrated with the structure of the apex.

The description of the mode of action of the vascular cambium is outdated and it is no correct to describe the ray initials as isodiametric. There seems to be some ambiguity in "uniseriate homogeneous rays are primitive and the multiseriate heterogeneous condition is a derived state, e.g. Pine compared with Oak or Beech". One might still tolerate that laboured distinction between "spring" and "summer" wood, were it not for the fact that the student is encouraged to examine some tropical timbers, "cut with a razor blade or sharp knife".

The section on flowers and fruits comprises some rather diffuse physiology and very little anatomy. It does however include the following gem: "many fruits are grown in the tropics and transported to the markets where they are sold". The reader is expected to be familiar with gibberellins, kinins, lysozyme, phytochrome, mitochondria and ribosomes but not with the basic features of a flower. He apparently needs also to be instructed that a fruit, in botanical parlance, is not necessarily tasty and juicy. Following a similar line of thought, if there is adequate background for the discussion of the action of ATP, IAA and DNA, then surely one can be more explicit than still to talk about "pectic substances" and "hemicelluloses".

The possible relationships between structure and function, as well as phylogenetic problems, are throughout dealt with in a superficial and facile manner, certainly belying any claim to an exposition of contemporary thought.

This book is little credit to its author or sponsors and, as recommended in the preface, some of us will certainly be "discussing the difficulties and significance of it with the class".

A. R. A. NOEL

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